Can text messages make you change?

Mobile phone-based interventions for tobacco and alcohol use reduction in adolescents

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Abstract

Mobile phone-based early interventions seem promising as means to address tobacco and problematic alcohol use in adolescents. They are appealing to adolescents, demonstrate small, but significant preventive effects, and are implemented at relatively low cost. Beyond questions regarding their effectiveness, little is known about how adolescents engage with these interventions and which adolescents might benefit most from them. The current thesis tries to extend the current knowledge by investigating 1) the effectiveness of a primarily mobile phone-based intervention to reduce or prevent problematic alcohol use in adolescents; 2) socio-demographic, health-related, and socio-cognitive moderators of the previously-mentioned intervention; and 3) engagement trajectories within a primarily mobile phone-based intervention to reduce tobacco smoking in adolescents. The results can be summarized as follows: (1) A mainly mobile phone-based intervention was effective at reducing the prevalence of problematic alcohol use in adolescents. (2) The most influential moderators of the effectiveness of the previously-mentioned intervention were smoking status and educational attainment. (3) Three engagement trajectories were observed in adolescents participating in a mobile phone-based smoking cessation programme: stable engagement, decreasing engagement, and stable non-engagement. Adolescents who were younger, had no immigrant background, perceived more benefits of quitting smoking, and reported binge drinking preceding the baseline assessment were more likely to exhibit stable engagement. The main conclusions of this thesis are that mobile phone-based early interventions can be effective at preventing problematic substance use of tobacco and alcohol; however, further efforts should be undertaken to optimize programmes for lower-educated adolescents who consume only one substance (alcohol or tobacco).

Zusammenfassung

Frühzeitige Interventionen mithilfe von Mobiltelefonen scheinen ein vielversprechendes Mittel zu sein, um den Tabak- und problematischen Alkoholkonsum von Jugendlichen vorzubeugen. Solche Interventionen scheinen besonders attraktiv, effektiv und mit verhältnismässig tiefen Kosten implementierbar. Man weiss jedoch noch relativ wenig darüber, wie sich Jugendliche darauf einlassen und welche Jugendliche am meisten davon profitieren. Die vorliegende Dissertation hat das Ziel, den aktuellen Wissenstand durch eine Untersuchung 1) der Effektivität einer mehrheitlich mobiltelefonbasierten Intervention zur Reduktion oder Prävention von problematischen Alkoholkonsum bei Jugendlichen und 2) deren Moderatoren; sowie 3) der Teilnahmeverläufe innerhalb einer mehrheitlich mobiltelefonbasierten Intervention zur Reduktion des Tabakkonsums bei Jugendlichen, zu erweitern. Die Hauptergebnisse lauten wie folgt: (1) die Prävalenz von problematischem Alkoholkonsum konnte bei Jugendlichen durch eine mehrheitlich mobiltelefonbasierte Intervention effektiv reduziert werden. (2) Die einflussreichsten Moderatoren waren das Rauchverhalten und das Bildungsniveau. (3) Drei verschiedene Teilnahmeverläufe wurden innerhalb eines mobiltelefonbasierten Programms zur Tabakreduktion bei Jugendlichen beobachtet: eine stabile Teilnahme, eine abnehmende Teilnahme sowie eine stabile Nicht-Teilnahme. Folgende Faktoren waren mit einer stabilen Teilnahme am Programm assoziiert: jüngeres Alter, kein Migrationshintergrund, selbstberichtete Vorteile eines Rauchstopps und risikoreicher Alkoholkonsum vor der Erstbefragung. Die Haupterkenntnis der vorliegenden Dissertation ist, dass frühzeitige mobiltelefonbasierte Interventionen Tabak- und problematischen Alkoholkonsum effektiv vorbeugen können. Nichtsdestotrotz sollten weitere Anstrengungen unternommen werden, um insbesondere Jugendliche mit tiefem Bildungsniveau und solche, die lediglich eine der beiden Substanzen (Alkohol oder Tabak) konsumieren, zu unterstützen.

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Contents

Abbreviations

AIC	Akaike information criterion
ASW	Average silhouette width
BMI	Body-mass-index
CBT	Cognitive behavioural therapy
CC	Complete-cases
CPD/CPW	Cigarettes per day / cigarettes per week
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
HAPA	Health Action Process Approach
HBSC Study	Health Behaviour in School-aged Children Study
ITT	Intention-to-treat
(G)LMM	(Generalized) Linear mixed models
LOCF	Last-observation-carried-forward
MAS	Missing-as-smoker
MCA	MobileCoach Alcohol
MCT(+)	MobileCoach Tobacco (+)
MI	Motivational Interviewing
Mi	Multiple imputation
OM	Optimal matching distance algorithm
RSOD	Risky single-occasion drinking
SMS	Short message service
TTM	Transtheoretical Model
VPA	Vigorous physical activity
WHO	World Health Organization

Figures

Tables

1. Introduction

Adolescence (defined in this thesis as between the ages of 15 and 19 years[1]) represents a period in life during which many young people discover or experiment with behaviours that are typically seen as adult behaviours, such as tobacco smoking or drinking alcohol (Inchley et al., 2016). The age of onset of substance use is, according to the World Mental Health Survey of the World Health Organization (WHO), similar across high-income countries, with the interquartile range typically being 14-21 years for alcohol, and 15–21 years for tobacco (Degenhardt et al., 2008). Experimenting with adult behaviours opens adolescents up to opportunities to gain skills, achieve greater autonomy from adults, and build meaningful social connections with peers (Costello, Copeland, & Angold, 2011). However, the exploration of these – sometimes risky – behaviours takes place at a stage when a person's cognitive functions are not yet fully developed. This results in increased vulnerability to mental and substance use disorders in adolescents (Bundeszentrale für gesundheitliche Aufklärung, 2013; U.S. Department of Health and Human Services, 2012; White, 2009). Contrary to older adult drug users, since most adolescents have not yet come to a level of drug dependence, the focus of practices and research are heavily on prevention, early interventions, and the reduction of harm in those who have begun to use substances (Stockings et al., 2016). The platforms through which this age group can be best reached also differ from those of adults. Educational settings seem ideal to deliver interventions, and technology-based interventions tend to be more appealing and have greater uptake in this age group than in adults (Coppo et al., 2014; Haug, Schaub, Venzin, Meyer, & John, 2013b; Inchley et al., 2016; Stanton & Grimshaw, 2013; Stockings et al., 2016; Thomas, McLellan, & Perera, 2013).

[1] Compared to other definitions of adolescence, as for example the definition of (United Nations Department of Economic and Social Affairs (UNESDA), 2015), which describes adolescence as age 10 to 24 years.

In the light of all this, the main aim of this thesis was to examine how cigarette smoking and problematic alcohol use can be best addressed in adolescents. In the introduction (Chapter 2), the main causes and risks of tobacco and alcohol use in adolescents are presented. What follows this is a brief overview of common and effective strategies to prevent tobacco and problematic alcohol use in adolescents, the main focus on substance-specific mobile phone-based prevention. After this theory-based introduction, the specific research questions of this thesis are presented in Chapter 3. Chapter 4 details three empirical studies that were undertaken, as part of this dissertation, to answer the research questions posed in Chapter 3. Study 1 evaluated the efficacy of a primarily mobile phone-based intervention to prevent or reduce problematic alcohol use in adolescents. Study 2 examined moderators of this mobile phone-based alcohol intervention's effectiveness. Finally, Study 3 looked at adolescents' patterns of engagement with a mobile phone-based tobacco intervention. In the final chapter of this thesis, Chapter 5, the findings of the three afore-mentioned studies are discussed and the implications of the results for future research and preventive practice explored.

2. Theoretical Background

2.1 Tobacco smoking and alcohol use among adolescents

Tobacco use is the most preventable cause of lost health (World Health Organization, 2017) that commonly has its origins in adolescence (U.S. Department of Health and Human Services, 2012). Problematic alcohol use, on the other hand, remains the leading cause of mortality and morbidity in adolescents (Marmet, Rehm, Gmel, Frick, & Gmel, 2014). Both behaviours constitute a major public health concern worldwide (Inchley et al., 2016). The WHO estimates that 20.7% of the global population is currently smoking cigarettes, which is the most common way of consuming tobacco. The average rates of current smoking among adults[2] has declined since 2007 (24% versus 21% in 2015) (World Health Organization, 2017). Similar to the trend among adults, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and the Health Behaviour in School-aged Children (HBSC) Study both identified decreases in weekly smoking among adolescents, since 1995 and 2009, respectively. Nevertheless, large variations in tobacco initiation and weekly smoking have been observed between countries and regions (European Monitoring Centre for Drugs and Drug Addiction, 2017; Inchley et al., 2016). In Switzerland, the prevalence of regular or occasional cigarette smoking is still higher than in middle- or low-income countries, being 24.0% in adolescents age 15-19 years and 37.3% in young adults age 20-24 years (Gmel, Kuendig, Notari, & Gmel, 2016; World Health Organization, 2017).

Alcohol use is even more prevalent than tobacco use, in adults (World Health Organization, 2014) as well as in adolescents (European Monitoring Centre for Drugs and Drug Addiction, 2017; Inchley et al., 2016). Latest trends for alcohol use in adolescents are somewhat conflicting. On one hand, the overall percentage of adolescents consuming alcohol has been

[2] The WHO reports (2014, 2017) define adults, however, as persons over 15 years old, which in light of the definition in this thesis would also include adolescents.

decreasing (European Monitoring Centre for Drugs and Drug Addiction, 2017; Inchley et al., 2016). On the other, the percentage of adolescents reporting risky single-occasion drinking (RSOD) has substantially increased (Inchley et al., 2016). Risky single-occasion drinking (also known as binge drinking) is often defined as drinking at least five standard drinks on a single occasion for men, and four drinks on a single occasion for women (Gmel, Kuntsche, & Rehm, 2011). In Switzerland, the prevalence of at least once-monthly RSOD is 13.7% in those 15–19 years old, and 16.7% in young adults between 20 and 24 (Gmel et al., 2016). Another form of problem drinking identified by the National Institutes of Health (2015) is the average daily consumption of more than two standard drinks by men, and one standard drink by women. Relative to that of RSOD, the prevalence of risky mean daily alcohol consumption in young people is low (0.5% at 15–19 years of age and 2.4% at 20–24 years of age) (Gmel et al., 2016). Furthermore, studies on adolescents have detected a high co-occurrence of cigarette smoking and risky alcohol drinking (Haug, Schaub, Gross, John, & Meyer, 2013; McKee & Weinberger, 2013).

A variety of motivations exist for tobacco and alcohol use in adolescents, which can be seen as natural or at least understandable. In general, these motives include the adolescent's wish to attain positive outcomes or avoid negative ones (Kuntsche et al., 2014). Adolescents may, for example, use cigarette smoking (Moran, Wechsler, & Rigotti, 2004) or alcohol drinking (Cooper, 1994) for bonding with peers, even when they use alcohol in an excessive way (Visser, Wheeler, Abraham, & Smith, 2013). For some, cigarette smoking and alcohol drinking are perceived as means to overcome shyness and initiate contact with peers (Sherman, Chassin, Sherman, Presson, & Macy, 2016; Visser et al., 2013). Other motives for substance use that have been discussed relate to coping with stressful situations, to conforming or fitting the norm, and to enhancement in social situations like parties (Cheney, Oman, Vesely, Aspy, & Tolma, 2014; Cooper, 1994; Kobus, 2003). However, tobacco and

alcohol use generate different risks to adolescents' physical and psychological health (Inchley et al., 2016). Adolescents smoking cigarettes are at higher risk for addiction to nicotine, the development of chronic disease, and the future use of marijuana or other illicit drugs (U.S. Department of Health and Human Services, 2012). More than alcohol use itself, it is alcohol misuse that is associated with adverse health consequences (Inchley et al., 2016). Risky single-occasion drinking (RSOD), the most widespread form of problematic alcohol in adolescents, is associated, in the long-term, with elevated risks for developing heart or liver disease or an alcohol use disorder. In the short-term, multiple social and interpersonal problems may result from RSOD; these include arguing with friends and parents, engaging in unplanned sexual activity, drinking and driving, committing or being a victim of assault, getting into trouble with the law, academic difficulties, unintended injuries, and suicide attempts (Hingson, Edwards, Heeren, & Rosenbloom, 2009; Hingson, Heeren, & Edwards, 2008; Kuntsche & Gmel, 2013).

2.2 Prevention of substance use among adolescents

Different terminologies are used in current literature to categorize prevention strategies, which themselves are a subdomain of Public Health strategies (Gutzwiller & Paccaud, 2007; Bundeszentrale für gesundheitliche Aufklärung, 2013; Stockings et al., 2016; Caspar, 2017). Relative to Public Health strategies, prevention strategies are directed towards a specific target; they aim to reduce health risks in individuals (Gutzwiller & Paccaud, 2007). Common to all definitions is the categorization of the prevention strategies into the different time windows when they are to be used. Some prevention strategies target the time before a risky behaviour (e.g., cigarette smoking or problematic alcohol use) has become evident. Other prevention strategies focus on the time after the risky behaviour has appeared, for either a relatively short or a longer period. These definitions are not only marked by the time, but also

by the context in which they are applied. Some prevention strategies target entire populations (e.g., through legislation, regulations, and law enforcement), whereas others target individuals (e.g., through programmes for substance-using youths who are at higher risk of acute adverse effects) (Stockings et al., 2016). Table 1 summarizes common terminologies currently used to describe prevention strategies in the German-speaking and English-speaking literature, without aiming to be exhaustive.

Table 1. Terminologies used to describe prevention strategies

Author(s)	**Terminology**	**Aim**			**Context**	
		Prevent onset	Prevent escalation	Reduce harm	Population -level	Individual -level
(Gutzwiller & Paccaud, 2007; Caspar, 2017; Pompidou Group / Council of Europe, 2006)	*Primary prevention*	X			X	
	Secondary prevention		X		X	X
	Tertiary prevention			X		X
(Bundeszentrale für gesundheitliche Aufklärung, 2013; Marsch & Borodovsky, 2016)	*Universal prevention*	X			X	
	Selective prevention	X	X			X
(Stockings et al., 2016)	*Prevention interventions*	X			X	
	Early interventions and harm reduction		X	X		X
	Treatment			X		X

Despite criticisms that have arisen on the categorization of prevention strategies (e.g., 'how distinct are 'harm reduction' and 'treatment'?'), these categories have been shown useful when evaluating and comparing the effectiveness of different prevention programmes (Caspar, 2017; Stockings et al., 2016). In this thesis, the terminology of the most recent systematic review of reviews (Stockings et al., 2016) assessing the effectiveness of prevention strategies in young people for tobacco, alcohol, and illicit drugs, will be adopted. Figure 1 displays the three categories, with examples postulated by Stockings et al. (Stockings et al., 2016).

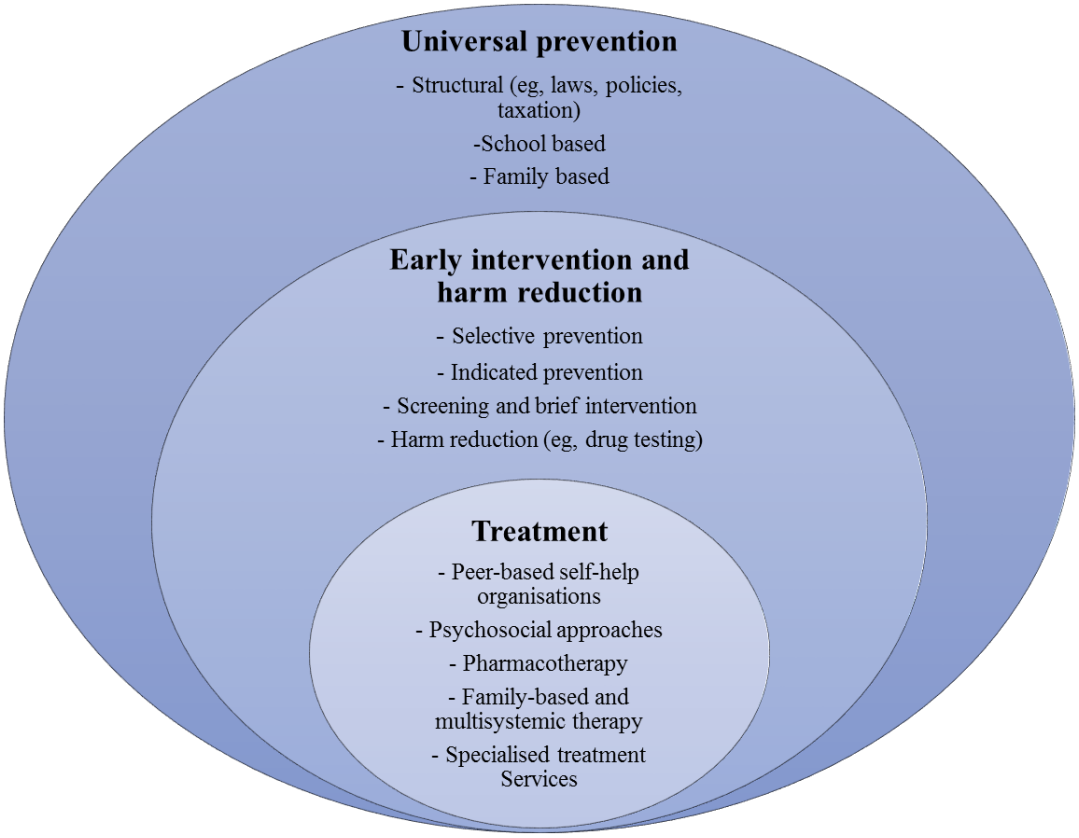

Figure 1. Categorization of interventions used to address substance use in young people, according to and adapted from (Stockings et al., 2016, p. 282)

While there is a wide range of preventive activities, this thesis focuses on early interventions in adolescents and, in particular, on screening and brief interventions. Screening and brief interventions are defined as interventions that (a) screen youths for the risk of problematic

substance use, and (b) provide some kind of feedback about the screening results, with the aim of reducing problematic substance use (Stockings et al., 2016).

2.3 Evidence-based early interventions for tobacco smoking and alcohol use among adolescents

Early interventions guided by one or more psychosocial theories have demonstrated to outperform such with no theoretical basis (Pentz, 2003). There are a variety of theories that can be used to plan and test behaviour change interventions (Webb, Sniehotta, & Michie, 2010). However, early intervention studies on adolescents could only recently be pooled to identify the most efficient theories. The latest Cochrane Review on smoking cessation interventions for young people (Stanton & Grimshaw, 2013) concluded that interventions seemed most effective when they combined elements from different theories, like Motivational Interviewing (MI, Rollnick & Miller, 1995) and Cognitive Behavioural Therapy (CBT, Beck, 2011). The aim of MI is to foster behaviour change in subjects by helping them to explore and resolve ambivalence in a subject-centred and directive way (Rollnick & Miller, 1995). In adolescents, for example, social advantages and health consequences of tobacco use are discussed to create ambivalence. The aim of CBT is to help subjects change their perceptions or reactions on situations that cause them problems, as for example change maladaptive reactions to stress (Beck, 2011).

Furthermore, the Cochrane Review concluded that young people had higher odds of becoming non-smokers if the smoking cessation interventions were tailored to their stage of change using the Transtheoretical Model (TTM) (Stanton & Grimshaw, 2013). There are two theories[3] that are most-known for dividing the act of changing behaviour into the so-called

[3] There are other frameworks making this distinction, e.g. the I-Change model (Vries, Mesters, Steeg, & Honing, 2005) or the Integrated Behavior-Change (IBC) Model (Hagger & Chatzisarantis, 2014).

'stages of change': the Transtheoretical Model (TTM, Prochaska & Diclemente, 1986) and the Health Action Process Approach (HAPA, Schwarzer, 2008). Both models suggest distinguishing between motivation processes that result in goal setting and volition processes that lead to the actual health behaviour. However, the TTM has been criticized as having certain deficiencies, including its assumption that each of the three stages of change have definite time spans (Sutton, 2001), which is why more recent studies have started to use the HAPA as a basis for their work. The HAPA assumes that, during the initial *pre-intentional stage*, outcome expectancies, risk perception, and perceived self-efficacy are influential social-cognitive predictors that promote the intention to act. In the subsequent *intentional stage*, planning processes are crucial to achieving the desired action. Once an action has been initiated, self-regulatory skills are important to help maintain the health behaviour (the *maintenance stage*) (Schwarzer, 2008). Many studies have found theoretical evidence for the postulated associations in smoking cessation (e.g. Berli et al., 2014; Scholz, Nagy, Göhner, Luszczynska, & Kliegel, 2009; Schwarzer & Luszczynska, 2008), and evidence for its practical utility in smoking cessation interventions (e.g. Free et al., 2011; Haug, Schaub, Venzin, Meyer, & John, 2013b; Satow, Lippke, & Schwarzer, 2009); with some of those studies including samples of young people (Haug, Schaub, Venzin, Meyer, & John, 2013b; Schwarzer & Luszczynska, 2008). In a study conducted on young people, however, some particularities were observed, e.g. risk perception not being related to intention to reduce smoking (Schwarzer & Luszczynska, 2008).

The most promising programmes for reducing problematic alcohol use in adolescents included elements like Motivational Interviewing (Foxcroft, Coombes, Wood, Allen, & Almeida Santimano, 2014; Stockings et al., 2016) and personalized normative feedback (Foxcroft, Moreira, Almeida Santimano, & Smith, 2015; Stockings et al., 2016) based on the Social Norms Approach (Perkins, 2003). The Social Norms approach assumes that adolescents typically overestimate the extent to which other peers approve the use of alcohol

(injunctive norm) and the quantity of alcohol that other peers consume (descriptive norm). Therefore, it hypothesizes that presenting accurate information to adolescents about peer-group drinking norms reduces the above-mentioned overestimations, as well as the perceived peer pressure to consume large quantities of alcohol (Perkins, 2003).

Even if the previous mentioned studies demonstrated that theory-based elements are associated with successful reduction of tobacco and problematic alcohol use in adolescents, authors of the most recent systematic review of reviews (Stockings et al., 2016) argued that empirical evidence that screening and brief interventions are helpful for tobacco-smoking adolescents was scarce and limited to primary-care settings. For adolescents drinking at harmful levels, the review concluded that individual interventions delivered face-to-face (rather than via computer) were most beneficial (Stockings et al., 2016). Yet, the review lacked information on the potential effectiveness of mobile phone-based interventions for reducing problematic alcohol use in adolescents. Similarly, it included only one Cochrane review on text messaging-based smoking cessation interventions (Whittaker, McRobbie, Bullen, Rodgers, & Gu, 2016), which, on closer inspection, reviewed studies conducted on smokers of any age who wanted to quit. These are clear limitations of the most recent systematic review on prevention in adolescents. Despite this, the authors concluded the following (Stockings et al., 2016, p. 290):

> With the rapid growth in new technologies and communication systems, it is evident that innovations need to be tailored for delivery to individuals, and for identification of new ways of responding to emerging psychoactive substances. Computer-delivered and mobile phone interventions to reduce substance use in young people are appealing because they allow users to manage the pace of the intervention, ensure privacy, tailor content to their needs, use multimedia to engage young people, and potentially have a wide reach at a low cost.

Mobile phones seem especially apt for delivering early interventions, since almost all adolescents own a mobile phone in most developed countries (GSM Association, 2013;

Inchley et al., 2016). In Switzerland, 98% of those who are 12-19 years old own a mobile phone, with 97% of these being smartphones (Waller, Willemse, Genner, Suter, & Süss, 2016). In comparison, only 76% of them own a computer. Most adolescents typically use their mobile phones on a daily basis (Waller et al., 2016). Furthermore, mobile phone-based interventions are often proclaimed as a promising way to bridge gaps in health disparities by delivering programmes to adolescents with different social and educational backgrounds who are already consuming specific substances like tobacco or alcohol (Sussman & Sun, 2009; Patton et al., 2014; Inchley et al., 2016; Marsch & Borodovsky, 2016; Suffoletto, 2016; Bock et al., 2016).

While several studies have been published reviewing the effectiveness of mobile phone-based interventions in adults (Free et al., 2013; Danielsson, Eriksson, & Allebeck, 2014; Spohr et al., 2015; Whittaker et al., 2016), to date, only one meta-analysis is available on the effectiveness of substance-specific mobile phone-based interventions in adolescents (Mason, Ola, Zaharakis, & Zhang, 2015). This meta-analysis included eleven studies on tobacco, but only three on alcohol. The mobile phone-based interventions ranged in duration from one day to one year, and adolescents were recruited across different settings; for example, emergency departments, schools/colleges, and via online advertisements. The authors of the meta-analysis concluded that there is sufficient evidence on the positive effects of such interventions on tobacco and alcohol use in adolescents, albeit with a rather small pooled effect size of 0.25; moreover, they acknowledged that, especially for alcohol use, more well-powered studies were needed to confirm this effect (Mason et al., 2015).

Despite this preliminary evidence on the effectiveness of mobile phone-based interventions in adolescents, to date no studies have evaluated which adolescents might benefit most (Mason et al., 2015). Also, little is known about the way adolescents engage with these interventions. Preliminary findings show that the retention of such interventions is high (86%-97% retention

rates) (Borland, Balmford, & Benda, 2013; Haug, Schaub, Venzin, Meyer, John, et al., 2013; Haug, Schaub, Venzin, Meyer, & John, 2013b). Answering to intervention prompts has been shown to decrease up to one third over the course of an entire intervention (Suffoletto et al., 2015); but most participants in two of the studies reported reading or having a quick look at text messages independently of their answer behaviour (Haug, Schaub, Venzin, Meyer, John, et al., 2013; Haug, Schaub, Venzin, Meyer, & John, 2013b). These seemingly contradictory findings beg the question: how can engagement with an intervention be conceptualized?

From studies on digital behaviour change interventions, reviewed by Perski et al. (2017), engagement seems to be conceptualised as "(1) the extent (e.g., amount, frequency, duration, depth) of usage; and (2) a subjective experience characterised by attention, interest and affect" (p. 258). The most common assumption in current literature is that some form of engagement is important for technology-based interventions to be effective (Donkin et al., 2011; Perski et al., 2017). Based on current findings, Perski et al. (2017) constructed a conceptual framework, which is depicted in Figure 2 and postulates that engagement with an intervention influences the target behaviour through specific mechanisms of action. On the other hand, engagement is influenced by different characteristics of the intervention itself, as well as by characteristics of the population and the setting in which the intervention takes place. One socio-cognitive factor that was assumed to be associated with engagement, for example, was motivation (Perski et al., 2017). Participants who were least and most motivated to change their behaviour were observed to disengage quickly from an intervention, since they either failed or succeeded in their intentions. Socio-demographic characteristics found to be associated with engagement were older age, higher educational attainment, and female gender (Perski et al., 2017). However, these are preliminary results, since no meta-analytic data are yet available.[4]

[4] For a more extensive discussion, see (Perski, Blandford, West, & Michie, 2017).

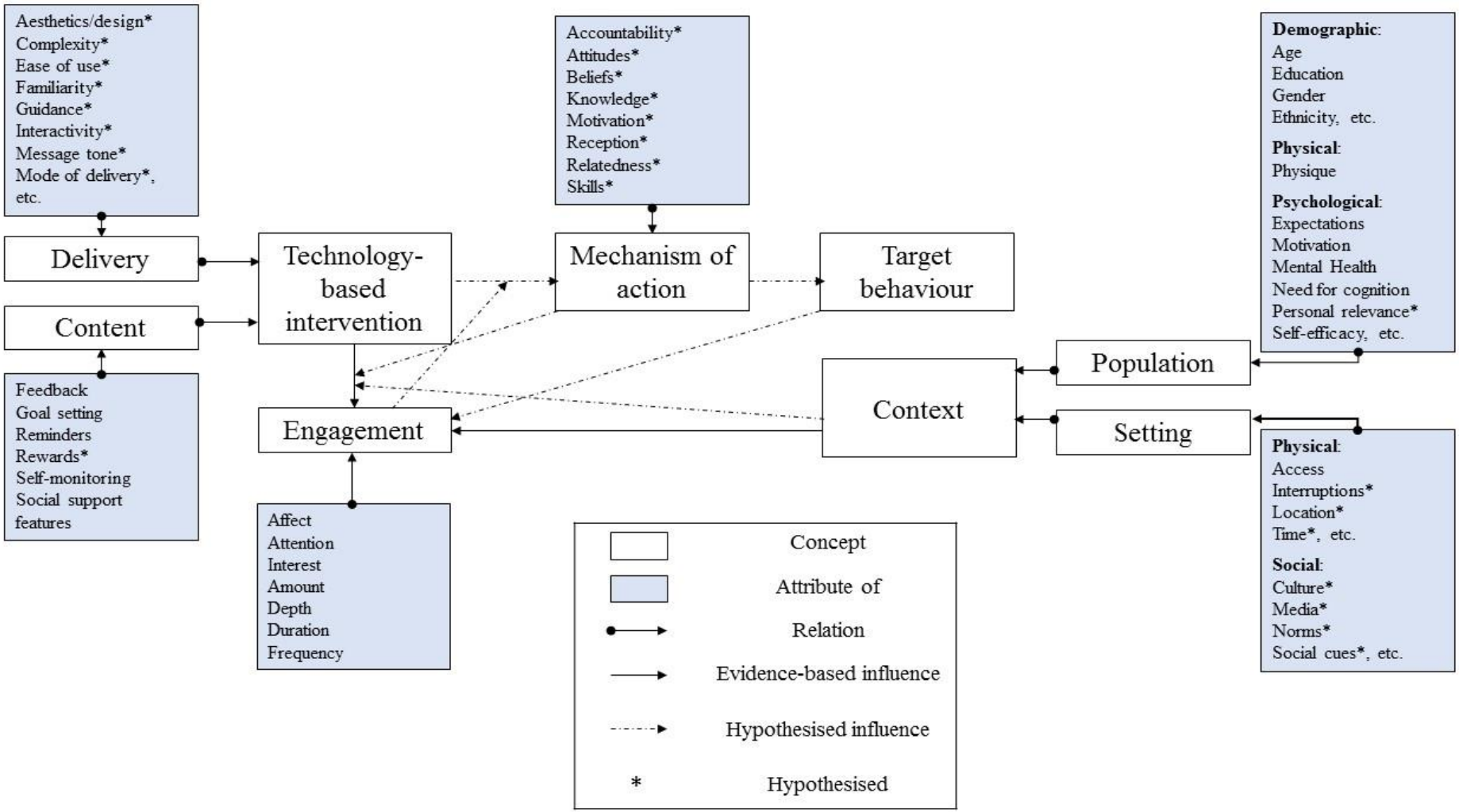

Figure 2. Conceptual framework of direct and indirect influences on engagement with technology-based interventions, according to and adapted from (Perski et al., 2017, p. 261)

Several studies have however shown that a) the relationship between a person's level of engagement with a given intervention and the intended outcomes might be more complex than postulated in the afore-mentioned framework (Balmford & Borland, 2014; Businelle et al., 2016; Saul, Amato, Cha, & Graham, 2016), and that b) other definitions of engagement might be more fruitful for optimizing and improving digital health interventions (O'Brien & Toms, 2008; Han et al., 2012; Yardley et al., 2016). For example, lowest engagement with a text messaging-based smoking cessation intervention was associated with best treatment outcomes (Balmford & Borland, 2014), while highest engagement with quit-specific features of an app-based smoking cessation intervention (e.g. Quit Tips or Medication Tips) were predictive for non-abstinence (Businelle et al., 2016). This and similar findings have led to several studies, proposing different forms of conceptualising and measuring engagement. For example, Han et al. (2012) proposed to distinguish between "active" and "passive" engagement within their study examining a online breast cancer support group; the former involves contributing to the intervention (e.g., by posting on an online discussion forum), while the latter merely involves following what others are doing (e.g., "lurking", reading what others have written, without commenting). Yardley et al. (2016) introduced the concept of "effective engagement", which they defined as "sufficient engagement with the intervention to achieve intended outcomes" (p. 833). In their work the authors discussed the potential of digital health programs to increase mastery in subjects so that the programs itself become obsolete, and also proposed a mixed method multi-dimensional approach to identify factors that facilitate this kind of engagement. Especially, they emphasize combining self-reported data on engaging content with objective data on usage patterns (Yardley et al., 2016). With respect to adolescents' engagement with mobile phone-based interventions, to date, no studies have been published evaluating engagement processes.

To summarize, there are good reasons to encourage research in this specific field of substance-specific mobile phone-based interventions. However, future research must overcome three main challenges to fulfil the expectations held for the preventive power of technology-based interventions: 1) Well-designed and adequately-powered, randomized controlled trials must be designed to replicate and thereby confirm previous findings (Mason, Benotsch, Way, Kim, & Snipes, 2014; Stanton & Grimshaw, 2013; Stockings et al., 2016). 2) Moderation and mediation processes must be studied to increase the effectiveness of existing interventions (Mason et al., 2015; Patton et al., 2014). And 3), engagement with mobile phone-based interventions must be examined, since this has been shown to be poor in other interventions forms and considered crucial to an intervention's effectiveness (Perski et al., 2017; Stockings et al., 2016; Yardley et al., 2016).

3. Specific Research Questions

There are many research questions that could be studied in this emerging field of substance-specific mobile phone-based interventions. Following the aforementioned recommendations, this thesis primarily focuses on the following three:

1) Can a mobile phone-based early intervention reduce problematic alcohol use in adolescents?

Concerning alcohol use in adolescents, the efficacy of interventions involving text messaging was based upon pilot studies with relatively small sample sizes (Mason et al., 2014). The first study of this thesis evaluated the efficacy of an optimized version of a previously-tested web- and text messaging-based programme (Haug, Schaub, Venzin, Meyer, John, et al., 2013) within an adequately-powered, cluster-randomized controlled trial. The intervention addressed adolescents, irrespective of the presence or level of problem drinking and, in so doing, tested potential iatrogenic effects of early interventions for non-problem drinkers.

2) Which adolescents might benefit most from a mobile phone-based early intervention for alcohol use?

Moderators of the effectiveness of mobile phone-based interventions have not been studied to date (Mason et al., 2014). Thus, the second study described in this thesis examined socio-demographic, health-related and socio-cognitive factors, which were already examined in either face-to-face or computer-based alcohol interventions and which were hypothesised to influence the effectiveness of the previously-mentioned intervention. The study concurrently included multiple moderators in a statistical model to determine which moderators were most important.

3) How do adolescents engage with a mobile phone-based intervention to reduce tobacco smoking and how is this engagement associated with intervention outcomes?

Little is known about adolescents' level and patterns of engagement with mobile phone-based interventions (Haug, Schaub, Venzin, Meyer, John, et al., 2013; Haug, Schaub, Venzin, Meyer, & John, 2013b; Suffoletto et al., 2015). The third study in this dissertation examined engagement with a mobile phone-based intervention designed to help adolescents reduce tobacco smoking. No prior studies had investigated engagement with a mobile phone-based programme in proactively-recruited adolescent smokers at different stages of change. More precisely, the study examined engagement trajectories and their association with participant characteristics and outcomes.

4. Empirical Studies

4.1 Efficacy of a web- and text messaging-based intervention to reduce problem drinking in adolescents: Results of a cluster-randomised controlled trial[5]

4.1.1 Introduction

Alcohol use is a major cause of disease burden in most countries worldwide (Lim et al., 2012). In the US, alcohol use disorders were associated with 15% and 24% of all deaths in young women and men aged 18–24 years, respectively (Rehm et al., 2014). Problem drinking in young people is associated with multiple social and interpersonal problems such as arguing with friends and parents, engaging in unplanned sexual activity, drinking and driving, assault, getting into trouble with the law, academic difficulties, unintended injuries, and suicidal acts; in the long term, problem drinkers exhibit an elevated risk of developing chronic conditions such as heart and liver disease or alcohol use disorders (Hingson et al., 2009, 2008; Kuntsche & Gmel, 2013).

Indicators of problem drinking are (a) average daily consumption of more than 2 standard drinks in men and 1 standard drink in women (National Institutes of Health, 2015) and (b) risky single-occasion drinking (RSOD, also known as binge drinking), defined as drinking at least 5 standard drinks on a single occasion in men and 4 drinks on a single occasion in women (Gmel et al., 2011). RSOD prevalence rates are particularly high in adolescence and young adulthood (Kuntsche, Rehm, & Gmel, 2004). In Switzerland, monthly RSOD prevalence is 32% in adolescents aged 15–19 years and 42% in young adults aged 20–24 years (Gmel, Kuendig, Notari, & Gmel, 2015). Relative to that of RSOD, the prevalence of

[5] For a similar version of this chapter see Haug, S., Paz Castro, R., Kowatsch, T., Filler, A., Dey, M., Schaub, M. P. (2016). Efficacy of a Web- and Text Messaging-Based Intervention to Reduce Problem Drinking in Adolescents: Results of a Cluster-Randomized Controlled Trial. *Journal of Consulting and Clinical Psychology, 85(2)*:147-159.

elevated mean daily consumption in young people is low (3% at 15–19 years of age and 4% at 20–24 years of age), and it almost always occurs in combination with RSOD (Gmel et al., 2015).

To date, most studies examining the efficacy of interventions designed to reduce problem drinking in young people targeted college or university students and included personalized normative feedback based on the social norms approach (Perkins, 2003). The latter is based on the assumption that students typically overestimate the extent by which other students approve the use of alcohol (injunctive norm) and the quantity of alcohol that other students actually consume (descriptive norm). An overestimation of peer alcohol use has been shown in several samples of young people (França, Dautzenberg, & Reynaud, 2010; Haug, Ulbricht, Hanke, Meyer, & John, 2011; Perkins, 2007) and was identified as one of the strongest predictors of alcohol consumption in this particular age group (Brooks-Russell, Simons-Morton, Haynie, Farhat, & Wang, 2013; Haug et al., 2011; Kypri & Langley, 2003; Neighbors, Lee, Lewis, Fossos, & Larimer, 2007). Presenting accurate information about peer group drinking norms is hypothesized to reduce the above-mentioned overestimation as well as the perceived peer pressure to consume high levels of alcohol (Perkins, 2002). Perceived peer drinking norm was also a relevant mediator of behavioural outcomes in multi-component programs addressing alcohol consumption among students (Paschall, Ringwalt, Wyatt, & DeJong, 2014; Walters, Vader, Harris, Field, & Jouriles, 2009). A systematic review on the efficacy of web- and computer-based personalized normative feedback in reducing problem drinking in young people reported small but significant effects on alcohol-related problems, binge drinking, quantity of alcohol consumed, frequency of alcohol consumed, and peak blood alcohol concentration (Foxcroft et al., 2015). However, it must be considered that personalized normative feedback was often embedded in multi-component programs that also incorporated other elements such as information on local outpatient alcohol counselling

services and elements derived from other theoretical approaches like outcome expectancies or protective behavioural strategies (Paschall, Antin, Ringwalt, & Saltz, 2011; Walters et al., 2009).

A recent review, which involved primarily student samples from the US and focused on computer- and web-based screening and brief interventions designed to reduce hazardous alcohol consumption, suggested that these interventions were effective in reducing alcohol consumption with follow-up periods of less than 12 months, but this was not observed with longer-term follow-up periods (Donoghue, Patton, Phillips, Deluca, & Drummond, 2014). Based on the available reviews and recently published RCTs on alcohol screenings and brief interventions for adolescents (Patton et al., 2014), electronic brief interventions could be considered to induce behavioural changes cost-effectively, and young people found them more acceptable relative to face-to-face approaches.

To date, computer and web-based brief interventions to reduce problem drinking typically consist of a single or a few intervention sessions in which participants receive tailored web-based or printed feedback, which typically consists of 7–8 pages of text and graphics (Donoghue et al., 2014; Foxcroft et al., 2015). While pictographic information provided via computer or the Internet have been shown to be appropriate to present personalized normative feedback, an additional provision of shorter and more frequent feedback messages might be a more effective approach to support and maintain behaviour change over a longer period. Text messaging is a suitable means of delivering short, repeated messages. This service allows cost-effective, instantaneous, direct delivery of messages to individuals at any time and location. Text messaging is beneficial in the field of alcohol prevention, because it allows delivery of individualized messages at times when young people typically drink alcohol, i.e. on weekends and late at night (Kuntsche & Robert, 2009). In Switzerland, as in most

developed countries, almost all (98%) adolescents between the ages of 12 and 19 own a mobile phone, and 97% of these phones are smartphones (Willemse et al., 2014).

Concerning alcohol use in young people, the efficacy of interventions involving text messaging has been assessed in 3 pilot studies with relatively small sample sizes (Mason et al., 2014; Moore et al., 2013; Suffoletto, Callaway, Kristan, Kraemer, & Clark, 2012) and 2 larger-scale studies (Haug, Schaub, Venzin, Meyer, John, et al., 2013; Suffoletto et al., 2014).

Suffoletto et al. (2014) evaluated the efficacy of an assessment and feedback intervention involving text messaging, provided after emergency department discharge, in young adults exhibiting hazardous alcohol consumption. At 9-month follow up, participants in the intervention group reported greater reductions in the number of RSOD days, lower RSOD prevalence, fewer drinks per drinking day, and lower alcohol-related injury incidence relative to participants in the control group, who received standard care (Suffoletto et al., 2015).

Haug et al. (2013) assessed the acceptance and initial efficacy of a combined, individually tailored web- and text messaging-based intervention designed to reduce problem drinking in Swiss vocational school students in a pre-post study. The results showed a significant reduction from 76% at baseline to 68% at 3-month follow up in the proportions of individuals reporting RSOD.

In the present study, we evaluated the efficacy of an optimized version of this programme within an adequately powered, cluster-randomized controlled trial. While previous studies either addressed interventions providing computer/web-based feedback or text messages, this study tested the efficacy of an intervention program combining the advantages of two communication channels – a comprehensive pictographic web-based feedback and concise text messages provided over a period of three months, some of which were sent on individually indicated typical drinking times.

The intervention addressed young people irrespective of the presence or level of problem drinking. With respect to data protection regulations, feasibility, and the avoidance of discrimination against certain students, the provision of an individualized primary prevention intervention has several advantages over secondary prevention interventions focusing on problem drinkers. However, few studies have assessed the efficacy or potential iatrogenic effects (Werch & Owen, 2002) of web-based alcohol interventions for non-problem drinkers (Bertholet et al., 2015b; Palfai, Winter, Lu, Rosenbloom, & Saitz, 2014). In order to address this, ancillary subgroup analyses included groups that differed with respect to the presence and level of problem drinking.

4.1.2 Methods

Study Objectives and Design

The study aimed to determine the efficacy of a combined web- and text messaging-based intervention designed to reduce problem drinking in young people. The study was registered at Current Controlled Trials ISRCTN (59944705, assigned 10 July 2014). The two-arm, parallel-group, cluster-randomised controlled trial used school class as a randomisation unit and compared the efficacy of the intervention to that of assessment only. The trial was conducted in Switzerland, and participants were recruited between September 2014 and March 2015. The 6-month follow-up assessments were conducted between March and September 2015, and the study protocol was published on 7 August 2014 (Haug, Kowatsch, Paz Castro, Filler, & Schaub, 2014). Students in vocational and upper secondary schools were invited to participate, irrespective of level of alcohol use. The intervention was based on the social norms approach (Perkins, 2003) but also included elements of major psychological models of health behaviour change such as social cognitive theory (McAlister, Perry, & Parcel, 2008) and the health action process approach (Schwarzer, 2008). Text messages were sent to participants over 3 months and tailored according to data gathered at baseline and

during repeated text message assessments. At 6-month follow up, we expected to observe lower RSOD prevalence for the preceding 30 days in students in the intervention group, relative to that observed in the control group. Secondary outcome measures included frequency of RSOD occasions in the preceding 30 days, quantity of alcohol consumed during a typical week in the preceding 30 days, estimated peak blood alcohol concentration, and overestimation of peer drinking norms. The study protocol was approved by the ethics committee of the philosophical faculty at the University of Zurich, Switzerland (date of approval: 24 June, 2014). The trial was executed in compliance with the Declaration of Helsinki.

The study was implemented as described in the study protocol (Haug et al., 2014), with the following modification: To consider the nested data structure for students in classes adequately (intra-class correlation for primary outcome was 9.1% and 8.4–11.6% for secondary outcomes), we performed generalized linear mixed modelling (GLMM, Laird & Ware, 1982) rather than generalized estimation equation analyses (Zeger, Liang, & Albert, 1988).

Participants, Setting, and Procedure

The intervention assessment involved vocational and upper secondary school students because of their heterogeneous educational level and age range, which was primarily 16–19 years. Alcohol consumption is considerably higher in this age group relative to that observed at a younger age (Gmel et al., 2015), and Internet use and text messaging are widespread (Willemse et al., 2014). Prevention specialist centres in the Swiss cantons of Zurich and Berne invited vocational and upper secondary schools to participate in a study examining the efficacy of a web- and text messaging-based programme designed to reduce problem drinking. Eleven vocational and upper secondary schools, with 80 classes in total, agreed to participate in the study.

Research assistants (psychology master's degree students or graduates) invited all of the students in the participating classes to take part in an online health survey during a regular school lesson reserved for health education. To reduce reporting bias, research assistants did not provide further information regarding the purpose of the study before screening was complete. Online screening was performed between September 2014 and March 2015 using tablet computers. Demographic data, general health, alcohol consumption, weekly physical activity, smoking status, and mobile phone ownership were assessed. The only inclusion criterion for study participation was ownership of a mobile phone. Eligible individuals were informed about data protection, the aim of the study, assessments, and reimbursement. Research assistants provided study and programme information online and on paper. Eligible individuals were informed that they could withdraw from participation at any time by sending a text message expressing this intention. To ensure sufficient participation, a reward of 10 Swiss francs was offered for participation in the study at both baseline- and follow-up assessment. After providing informed consent online, all participants were invited to choose a username and provide a mobile phone number.

Subsequently, participants in the intervention group were provided with additional questions, which were necessary in tailoring intervention content, and received individualized feedback, which was based on the social norms approach, via their tablet computers (see Intervention section). During the subsequent 3 months, the intervention group received 1–3 individually tailored text messages per week to reduce problem drinking. The assessment-only group received no intervention.

Follow-up assessments were conducted using tablet computers, during regular lessons and under the supervision of research assistants, 6 months later. Computer-assisted telephone interviews were conducted when assessments could not take place during a school lesson because of vacations, class resolution, or study participants' absence from class (n = 163).

Randomisation and Allocation Concealment

To avoid spill-over effects within classes, we conducted a cluster-randomised controlled trial using school class as a randomisation unit. Because of the heterogeneity of apprentices in the different vocational and upper secondary school classes (e.g. concerning sex or profession), we used separate randomisation lists for each school (stratified randomisation). Furthermore, to approximate sample size equality in the study groups, we used block randomisation with computer-generated, randomly permuted blocks of 4 school classes (Pocock, 1994).

Research assistants supervising the baseline assessment in the vocational schools were blinded to the group allocation of school classes. In addition, group allocation was not revealed to participants until they had provided their informed consent, username, mobile phone number, and baseline data. Furthermore, the research assistants who performed the computer-assisted follow up assessments for primary and secondary outcomes were blinded to the group allocation.

Sample Size Calculation

An estimation of effect size was based on the results of the pre-post study in which the initial efficacy of the programme was assessed (Haug et al., 2013). This study revealed a reduction, from 76% at baseline to 68% at follow up, in the proportion of individuals who reported at least 1 RSOD occasion during the preceding month. Improvements in the content and tailoring of the intervention were expected to result in improved efficacy. Based on these considerations, the proportions of individuals reporting at least 1 RSOD occasion in the month preceding follow-up were estimated at 76% in the control group and 66% or lower in the intervention group. Each study groups required 322 participants to ensure 80% power in an $\chi 2$ test ($\alpha = 5\%$, 2 sided) and detect differences based on a calculation using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). As students are nested within school classes, a

potential design effect required consideration. Based on the pre-post study conducted (Haug et al., 2013), we expected an average cluster size of 10 participants per class and an intra-cluster correlation coefficient of 0.05. This resulted in a design effect of 1.45. Multiplying this design effect by the required size for a non-nested sample (n = 322) resulted in a requirement for 467 participants per study group and a total sample size of 934.

Intervention

Overview

The intervention programme, *MobileCoach Alcohol*, is a combined, individually tailored intervention with a web- and text messaging-based part. It combines a single web-based feedback provided immediately after a baseline assessment and individually tailored text messages provided over the intervention period of 3 months. The division into a web-based and a text messaging part was driven by time constraints (providing a comprehensive feedback within a school lesson, whereas short text messages were sent repeatedly during leisure time), considered the cognitive capacity and motivation of students (higher for shorter intervention elements) and took into account that each technology has its own advantages.

Technological Background

The intervention programme, *MobileCoach Alcohol*, was developed using the MobileCoach system. Details of the system were described in (Haug et al., 2014). The source code for the MobileCoach system is available as an open-source project on http://mobile-coach.eu. Password protection and Secure Sockets Layer encoding were used to ensure the privacy and safety of data transfer.

Theoretical Background

The web-based part of the intervention primarily provided normative feedback based on the social norms approach (Perkins, 2003). The text messaging-based part of the intervention primarily relied on the following socio-cognitive constructs from major psychological models of health behaviour change such as social cognitive theory (McAlister et al., 2008) and the health action process approach (Schwarzer, 2008): outcome expectations, motivation to drink within low-risk limits, self-efficacy, and planning processes.

Web-based Feedback

The web-based feedback was based on age- and gender-specific norms for alcohol consumption from a previous study (Gmel, Venzin, Marmet, Danko, & Labhart, 2012) that assessed heavy drinking occasions, alcohol volume, and the maximum number of drinks consumed on a single occasion in 973 vocational and upper secondary school students in the canton of Zurich, Switzerland. The web-based feedback included individually tailored graphical and textual information concerning (1) the number of drinks consumed per week in relation to the age and gender-specific reference group, (2) financial costs of drinking, (3) calories consumed with alcoholic drinks, and (4) number of RSOD occasions in relation to the age- and gender-specific reference group.

Text Messages

On the first level, the content and number of text messages were tailored according to baseline drinking patterns. Participants were assigned to one of 3 risk groups derived from (Gmel et al., 2011; National Institutes of Health, 2015) according to their baseline drinking patterns: (1) low risk: No RSOD occasions during the preceding 30 days and ≤ 14 (7 for girls) standard drinks consumed during a typical week, (2) medium risk: 1 or 2 RSOD occasions during the preceding 30 days or no RSOD occasions during the preceding 30 days and ≥ 14 (7 for girls)

standard drinks consumed during a typical week, and (3) high risk: > 2 RSOD occasions during the preceding 30 days.

On the second level, the content of the text messages was tailored according to individual values for the following baseline variables: sex, motivation to reduce alcohol consumption, alcohol-related problems, typical drinking day and time, estimated peak blood alcohol concentration during the preceding 30 days, positive outcome expectancies, typical drinking situations, strategies to resist alcohol in different drinking situations, and assessment location (canton of Zurich vs. canton of Berne). Participants from all risk groups received text messages for 3 months.

Text messages for the low risk group focused on (a) motivation for drinking within low-risk limits using individual data concerning positive outcome expectancies derived from a list provided by (Babor & Higgins-Biddle, 2001) and (b) strategies to resist alcohol in different drinking situations, using individual data obtained using the adolescent version of the Drinking Refusal Self-Efficacy Questionnaire (Young, Hasking, Oei, & Loveday, 2007).

Within the medium risk group, the text messages focused on (a) motivation to drink within low risk limits, using individual data concerning positive outcome expectancies derived from a list provided by (Babor & Higgins-Biddle, 2001); (b) alcohol-related problems, established using individual data on previous alcohol-related problems; (c) estimated peak blood alcohol concentration and related risk calculated using data concerning sex, body weight, and maximum number of drinks consumed on a single occasion in the preceding month; and (d) strategies to resist alcohol in different drinking situations, established using data concerning individual drinking situations and chosen strategies for resisting alcohol. Text messages concerning the last-mentioned category were sent on individually indicated typical drinking days and times.

Similar to those in the medium risk group, participants in the high risk group received 2 text messages per week from the content categories described above (a–d). In addition, they received information regarding local outpatient alcohol counselling services according to assessment location. Sample text messages for the different risk groups and content categories are shown in Table 2.

Table 2. Sample text messages derived from individual data

Risk group	Content category	Individual data considered	Resulting text message
Low risk	Motivation to drink within low-risk limits	Responded 'Yes' for the item: 'If I drink within low-risk limits, other people will respect me.'	Hey Cindy23 You're right; if you drink alcohol moderately, you will be respected by others, able to control your behaviour, and will not behave like in this Video.
Medium risk	Strategies to resist alcohol in different drinking situations	Individually chosen if-then plan to resist alcohol in a tempting drinking situation (party): 'When I am at a party, I have soft drinks every now and then.'	Hey Luca. Congratulations! It`s a good decision to have soft drinks every now and then when you are at a party! Non-alcoholic drinks provide your body with important minerals and are a thirst-quenching alternative.
High risk	Local outpatient services for alcohol counselling	Assessment location: Zurich	Hi Robin. Are you concerned about your own alcohol intake or that of a friend? Talking to someone about it can be really helpful. The website www.alcocheck.ch can offer you support. Write an e-mail to info@alcocheck.ch or call 044 444 77.

Irrespective of risk group, 3 short message service (SMS) text message assessments were performed during the intervention period: (1) An SMS quiz on the metabolism of alcohol, for which participants received immediate individualized feedback on their answers, and if they did not respond within 48 hours, they were sent the correct response. (2) A message contest that required participants to create a text message to motivate other participants to drink within low-risk limits. The best text message, rated weekly by an alcohol prevention specialist from the Swiss Research Institute for Public Health and Addiction, was sent anonymously to all other participants after 48 hours. (3) An SMS assessment of RSOD within the preceding week, which included immediate individualized feedback.

The text messages typically contained 150–300 characters. Several text messages also included web links to thematically appropriate video clips, pictures, and websites. Sample text messages are displayed in Table 2.

Participants in the low risk group received 16 text messages (1 welcome message, 3 assessment messages, 11 tailored feedback messages, and 1 goodbye message). Participants in the medium- and high-risk groups received 27 text messages (1 welcome message, 3 assessment messages, 22 tailored feedback messages, and 1 goodbye message).

The total number of different text messages across all risk groups was 119 (low risk: 39, medium risk: 95, high risk: 97; due to overlapping/identical text messages they do not add up to 119). As many text messages contained individual values (e.g., estimated peak blood alcohol concentration) or weekly changing top messages from the message contest, the variety of text messages was much larger.

Control Group

Participants in the assessment-only group did not receive any of the previously described interventional elements of the MobileCoach Alcohol programme.

Assessments and Outcomes

The online baseline screening assessment included the following demographic and health-related variables: sex, age, school education, immigration background, general health, physical activity, and tobacco smoking. The following common levels of educational attainment in Switzerland were assessed: (1) secondary school, (2) vocational school, and (3) technical/high school or university. In further analysis, we collapsed vocational school and technical/high school or university into a high educational level, and secondary school was coded as a low educational level. We assessed countries of birth in students' parents, to identify a potential immigrant background. Based on this information, participants were assigned to one of the following categories: (1) neither parent born outside Switzerland, (2) 1 parent born outside Switzerland, or (3) both parents born outside Switzerland. In the analysis, we collapsed 1- and 2-sided immigrant backgrounds into a single category and compared it to a non-immigrant background.

Self-rated general health (Idler & Benyamini, 1997) was assessed using the following item: 'Would you say that your general health is: (1) excellent, (2) very good, (3) good, (4) fair, or (5) poor?' Self-reported moderate to vigorous physical activity was measured using the following question derived from the Health Behaviour in School Aged Children study (Suppli et al., 2013): 'Outside school, how many hours per week do you exercise or participate in sports that make you sweat or out of breath?' Tobacco smoking was assessed using the following question: 'Do you currently smoke cigarettes or have you smoked in the past?' with the following response options: (1) I smoke cigarettes daily; (2) I smoke cigarettes occasionally but not daily; (3) I smoked cigarettes in the past, but I do not smoke anymore; and (4) I have never smoked cigarettes or have smoked less than 100 cigarettes throughout my life.

Baseline and follow up assessments included the following variables concerning alcohol use: (a) RSOD prevalence in the preceding 30 days, assessed by asking participants to report the number of standard drinks consumed on the heaviest drinking occasion in the preceding 30 days. Examples of standard drinks containing 12–14 g of ethanol were provided for beer, wine, spirits, alcopops and cocktails, along with conversion values (e.g. three 0.5 l cans of beer = 6 standard drinks). RSOD was defined as drinking at least 5 drinks on a single occasion in men and 4 drinks on a single occasion in women (Gmel et al., 2011).

(b) Frequency of RSOD occasions in the preceding 30 days ('How often did you have 5 (boys; girls: 4) or more drinks on a single occasion in the last 30 days?').

(c) Quantity of alcohol consumed, assessed via a 7-day drinking calendar similar to the Daily Drinking Questionnaire (R. L. Collins, Parks, & Marlatt, 1985), for which participants were asked to think about a typical week in the preceding month and record the number of standard drinks they typically consumed each day during that week.

(d) Estimated peak blood alcohol concentration, assessed by asking participants to report the number of standard drinks consumed and the duration of the heaviest drinking episode in the preceding 30 days. This information was used, along with the sex and weight, to estimate peak blood alcohol concentration based on the Widmark Formula (National Highway Traffic Safety Administration, 1994; Yang, Fung, & Tam, 2009).

(e) Overestimation of peer drinking norms using reference data from Gmel et al. (2012) and items derived from Haug et al. (2011), who used modified versions of the first and second consumption items of the Alcohol Use Disorders Identification Test (Bradley et al., 2007; Haug et al., 2011): 'How often does a typical (male/female) adolescent at the age of (xx years) have a drink containing alcohol?' and 'How many drinks does a typical (male/female) adolescent at the age of (xx years) years have on a typical day when drinking alcohol?' The

prevalence of overestimation of peer drinking norms was calculated by multiplying the indicated alcohol consumption quantity and frequency for a typical (male/female) adolescent at the corresponding age and subtracting this amount from the reference data (Gmel et al., 2012). Values of the perceived norm that were above those of the reference/actual norm were interpreted as overestimation.

The primary outcome of the planned study was RSOD in the 30 days preceding follow-up assessment. Secondary outcomes included (a) frequency of RSOD occasions in the 30 days preceding follow-up assessment, (b) estimated peak blood alcohol concentration in the preceding 30 days, (c) number of standard drinks consumed in a typical week during the preceding month, and (d) overestimation of peer drinking norms.

Indicators of program use and program attrition among participants of the intervention group were examined. Log files of the MobileCoach system in which all incoming and outgoing text messages were recorded were analyzed to obtain the number of participants who unsubscribed from the program (program attrition). At follow-up, the usage of text messages was assessed as well by asking participants whether they had received text messages regularly and if so (1) read through the text messages thoroughly, (2) took a quick look at the text messages, or (3) did not read the text messages. Furthermore, it was assessed whether the number of received text messages was appropriate or whether the participants would have preferred fewer or more messages.

Data Analysis

We initially examined the data for outliers, based on self-reported numbers of standard drinks, which were entered as free text. Based on a visual inspection of the distributions and the recommendations of Osborne and Overbay (2004), outliers were identified at more than 3 standard deviations above the mean and adjusted to 3 standard deviations above the mean.

To test for baseline differences between participants of the intervention and control group, chi-square tests were performed for categorical variables, and t tests and Mann-Whitney U tests were performed for continuous variables. To assess attrition bias we also used chi-square tests for categorical variables and Mann-Whitney U-tests and t tests for continuous variables to test whether participants lost to follow up differed from those who responded as a function of study group (intervention vs. control group).

Intervention effects for binary outcomes were tested using GLMM; intervention effects for continuous outcomes were analysed using linear mixed modelling. Analyses of binary outcomes focused on follow-up values. Independent variables included baseline values for the interesting binary variables, variables for which baseline or attrition differences were observed (fixed effects), and class as a single random effect (random intercept). Analyses of continuous outcomes included change in score from baseline to follow up as the dependent variable. Independent variables included baseline values, variables for which baseline or attrition differences were observed (fixed effects), and class as a single random effect (random intercept). This model controlled for the correlation between baseline and follow-up outcome scores and did not require a random effect for time or a time × group interaction term to interpret intervention effects (Twisk, 2013). Finally, GLMM and linear mixed modelling were used in ancillary analyses of the outcomes used in the main analyses, with the low-, medium-, and high-risk groups analysed separately. Intra-class correlation for primary and secondary outcomes ranged from 8.4% to 11.6% in the overall analyses and from 5.8% to 52% in the subgroup analyses. All analyses were based on a complete-case (CC) dataset and an intention-to-treat (ITT) dataset with imputation of continuous missing follow-up data based on expectation maximization, and with imputation of dichotomous missing follow-up data based on predictive mean matching (Hothorn & Everitt, 2014; Van Buuren, 2012). Distributions of outcomes (e.g. skew and kurtosis) and missing-at-random requirements for

missing data were checked prior to performing the main analyses. Results with a Type I error rate of $p < 0.05$ in two-sided tests were considered statistically significant. Analyses were performed using SPSS version 22 and R version 3.2.1 via lme4 (Bates, Maechler, Bolker, & Walker, 2014) and mice (Buuren & Groothuis-Oudshoorn, 2011) packages.

4.1.3 Results

Study Participation

Figure 3 depicts participants' progression through the trial. At online screening assessment, 1,399 students were present in 80 classes. Of these, 1,371 (98.0%) agreed to participate and completed the health survey, 1,355 met the inclusion criterion of ownership of a mobile phone, and 1,041 (76.8%) ultimately participated in the study. Forty-three classes containing 547 students in total were randomly assigned to the intervention group, and 37 classes containing 494 students in total were assigned to the control group. Follow-up assessments were completed by 511 (93.4%) and 455 (92.1%) participants in the intervention and control groups, respectively.

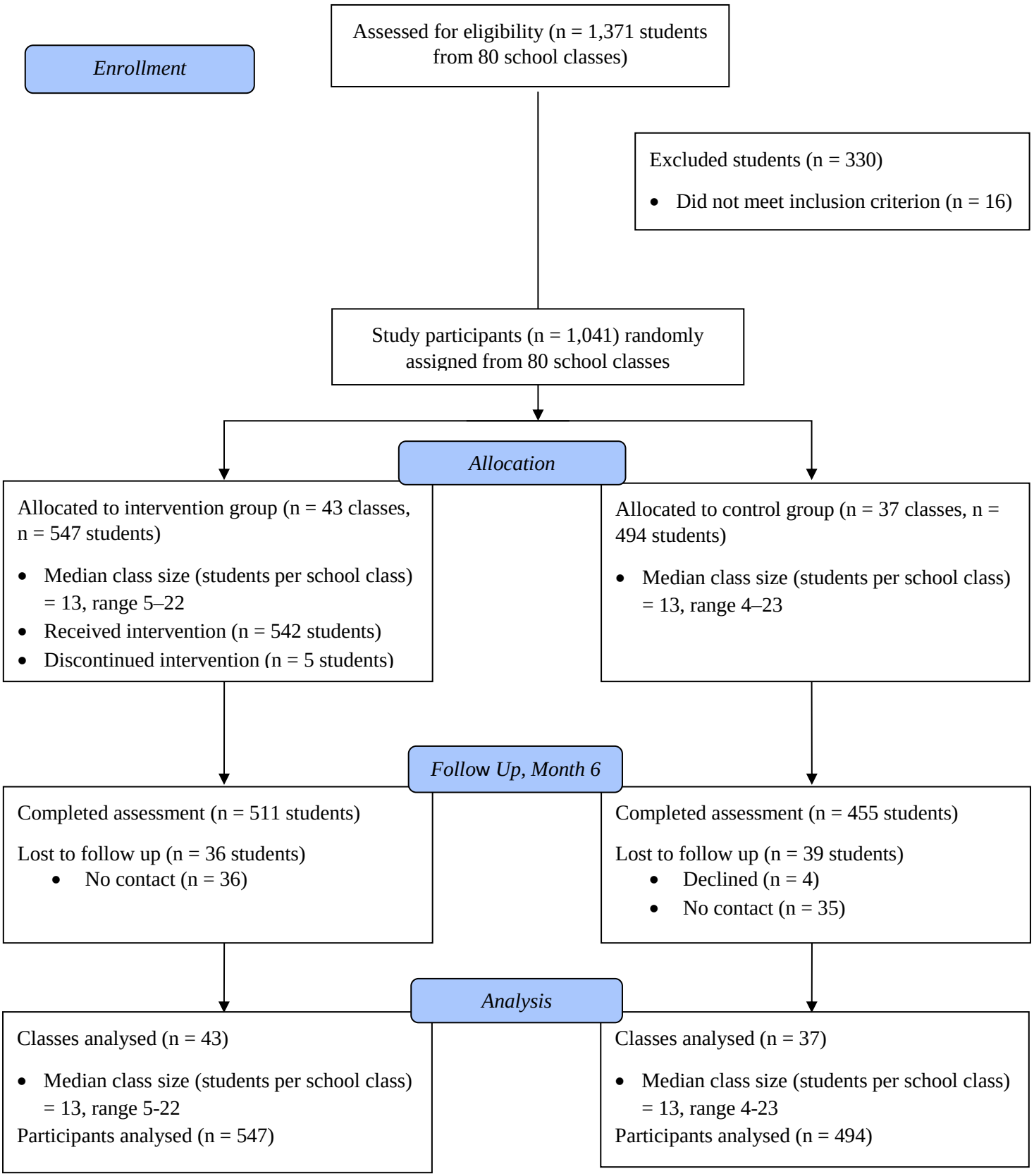

Figure 3. Participants' progress through the trial in Study 1

Programme Attrition and Use

During the intervention programme, which lasted for 12 weeks, 5 of the 547 (0.9%) programme participants withdrew their participation. Of 509 participants with valid follow-up data, 479 (94.1%) indicated that they had received text messages regularly. Of these, 65.6% (315) indicated that they 'read the SMS messages thoroughly', 32.6% (156) reported that they 'took a quick look at the SMS messages', and 1.7% (8) chose the predefined response category 'I did not read the SMS messages'. The number of text messages received was rated as appropriate by 71.5% (337/471) of participants; 10.0% (47/471) would have preferred fewer messages, 8.7% (41/471) would have preferred more text messages, and 9.8% (46/471) were no longer able to evaluate the appropriateness of the number of text messages received.

Sample Characteristics

Baseline characteristics for the study sample are shown in Table 3. Baseline differences between the intervention and control groups were detected only for smoking status, with a significantly higher proportion of smokers in the intervention group ($\chi 2 = 10.4$, $p = .01$).

Concerning attrition bias, the analysis revealed that intervention group participants who were lost to follow up were more likely to report a low educational level ($\chi 2 = 6.6$, $df = 2$, $p < .01$) and estimate the quantity of alcohol consumed by peers to be low ($\chi 2 = 17.3$, $df = 7$, $p = .02$) compared to control group participants who were lost to follow up.

Table 3. Baseline characteristics of the study 1 sample. Values represent n (%) unless stated otherwise.

Variable	Intervention *n* = 547	Control *n* = 494	Total *N* = 1,041	*p* [a]
Sex				.49[b]
Male	264 (48.3%)	229 (46.4%)	493 (47.4%)	
Female	283 (51.7%)	265 (53.6%)	548 (52.6%)	
Age, *M (SD)*	16.9 (1.6)	16.8 (1.4)	16.8 (1.6)	.83[c]
Immigration background				.42[b]
No immigration background	320 (58.5%)	272 (55.1%)	592 (56.9%)	
One parent born outside Switzerland	117 (21.4%)	107 (21.7%)	224 (21.5%)	
Both parents born outside Switzerland	110 (20.1%)	115 (23.3%)	225 (21.6%)	
Education				.41[b]
Secondary school	489 (89.4%)	445 (90.1%)	934 (89.7%)	
Vocational school	19 (3.5%)	22 (4.5%)	41 (3.9%)	
Technical/high school or university	39 (7.1%)	27 (5.5%)	66 (6.3%)	
Body mass index, *M (SD)*	21.8 (9.5)	21.5 (7.4)	21.6 (8.5)	.50[c]
Tobacco smoking status				.01[b]
Daily smoker	82 (15.0%)	58 (11.7%)	140 (13.4%)	
Occasional smoker	70 (12.8%)	40 (8.1%)	110 (10.5%)	
Former smoker	16 (2.9%)	24 (4.9%)	40 (3.8%)	
Non-smoker	378 (69.1%)	372 (75.3%)	750 (72.0%)	
RSOD, preceding 30 days				.14[b]
No	289 (52.8%)	283 (57.3%)	572 (54.9%)	
Yes	258 (47.2%)	211 (42.7%)	469 (45.1%)	
RSOD frequency, preceding 30 days, *M (SD)*	0.7 (1.2)	0.7 (1.1)	0.7 (1.2)	.28[d]

Number of standard drinks consumed in a typical week in the preceding 30 days, *M (SD)*	5.5 (8.4)	4.8 (6.9)	5.1 (7.8)	.52[d]
Estimated peak blood alcohol concentration in the preceding 30 days, *M (SD)*	1.1 (1.1)	1.0 (1.1)	1.1 (1.1)	.21[d]
Drinking risk group				.31[b]
Low	286 (52.3%)	278 (56.3%)	564 (54.2%)	
Medium	181 (33.1%)	142 (28.7%)	323 (31.0%)	
High	80 (14.6%)	74 (15.0%)	154 (14.8%)	
Overestimation of peer drinking norms				.37[b]
No	307 (56.1%)	291 (58.9%)	598 (57.4%)	
Yes	240 (43.9%)	203 (41.1%)	443 (42.6%)	

[a] *p* values for the comparison of the intervention and control groups, [b] χ^2 test, [c] *t* test, [d] *U* test.

RSOD: risky single-occasion drinking

Primary Outcome Analysis

The results of the ITT analysis examining RSOD prevalence are displayed in Table 4 and Figure 4. In the 30 days preceding follow-up assessment, RSOD prevalence decreased by 5.9% (from 47.2% to 41.3%) in the intervention group and increased by 2.6% (from 42.7% to 45.3%) in the control group, relative to that observed at baseline. This group effect was significant in the ITT analysis (OR = 0.62, $p < .01$) but not in the CC analysis (OR = 0.79, $p = .24$).

Table 4. Intervention effects for dichotomous outcomes

	Intervention (n = 547)			Control (n = 494)					
	Baseline	Follow up	Diff.	Baseline	Follow up	Diff.	*z*	*p*	OR [95% CI]
Intention-to-treat analysis									
RSOD, preceding 30 days	258 (47.2%)	226 (41.3%)	-5.9%	211 (42.7%)	224 (45.3%)	2.6%	-2.75	<.01	0.62 [0.44, 0.87]
Overestimation of peer group drinking norms	240 (43.9%)	234 (42.8%)	-1.1%	203 (41.1%)	199 (40.3%)	-0.8%	0.39	.69	1.06 [0.79, 1.42]
Complete-cases analysis									
RSOD, preceding 30 days	241 (47.3%)	221 (43.3%)	-4.0%	187 (41.1%)	194 (42.6%)	1.5%	-1.17	.24	0.79 [0.54, 1.17]
Overestimation of peer drinking norms	227 (44.5%)	232 (45.4%)	0.9%	193 (42.4%)	182 (40.0%)	-2.4%	1.31	.19	1.22 [0.91, 1.65]

Logistic generalized linear mixed models with group as a fixed factor; school classes as the random intercept; follow-up values as outcomes; and baseline scores, smoking status, educational level and misperception of quantity of peer alcohol consumption at baseline as covariates. RSOD: risky single-occasion drinking.

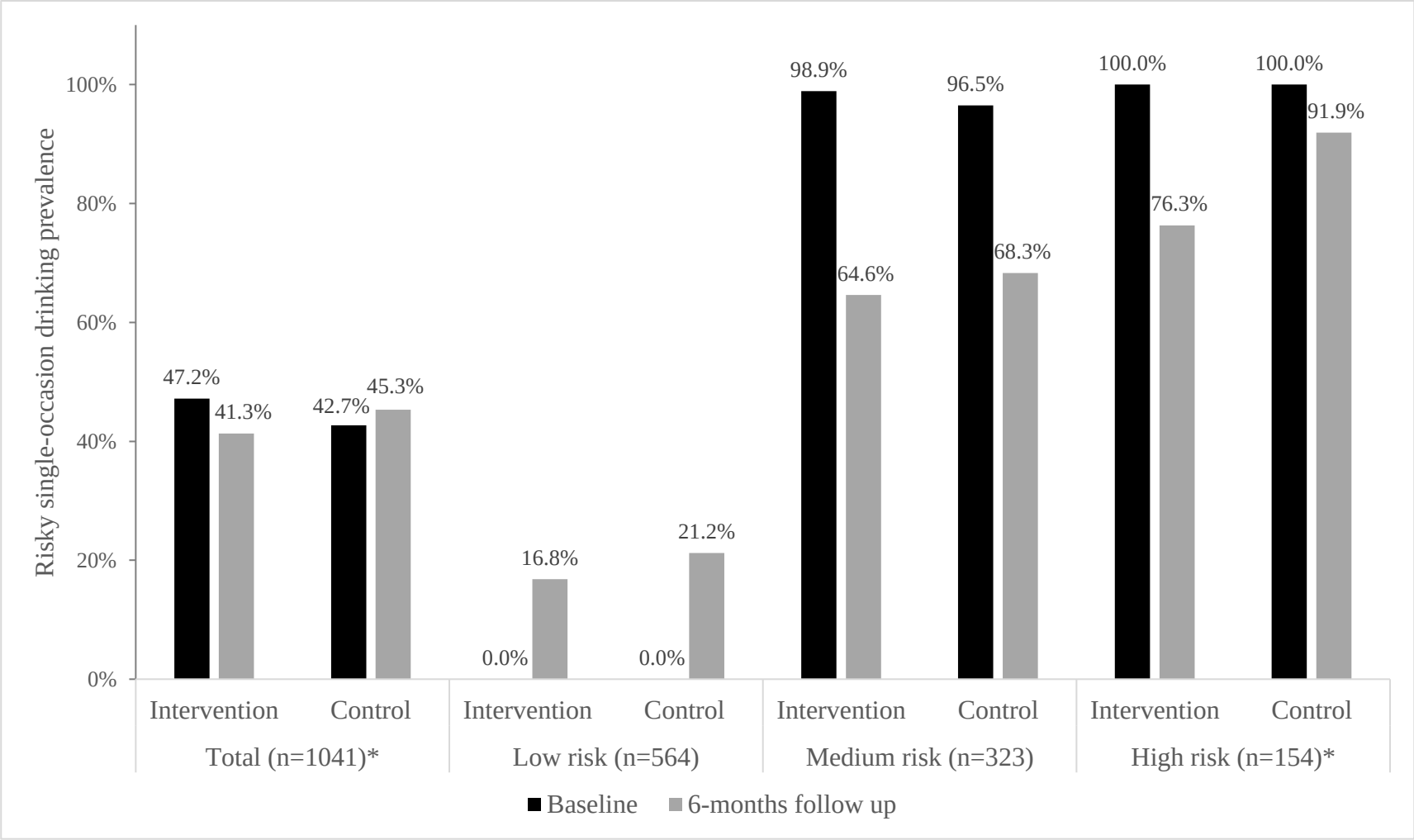

Figure 4. Risky single-occasion drinking prevalence by study condition and drinking risk group based on intention to treat analysis. *Significant difference between intervention and control group with $p < .05$

Secondary Outcome Analysis

Results concerning secondary outcomes are summarised in Tables 4 and 5. As the results of ITT analysis and CC analysis did not differ with respect to statistical significance, only those for the ITT analysis are reported. No significant group effect was observed for pre-post difference in RSOD frequency (-0.07 vs. 0.05, p = .19). Quantity of alcohol consumed in a typical week decreased by 0.94 standard drinks in the intervention group and 0.37 standard drinks in the control group (p = .58) from baseline to follow up assessment. Pre-post differences in estimated peak blood alcohol concentration (-0.14 in the intervention group and -0.03 in the control group, p = .16) and overestimation of peer drinking norms (-1.1% in the intervention group and -0.8% in the control group, p = 0.69) did not differ significantly between groups.

Table 5. Intervention effects for continuous outcomes

	Intervention (n = 547)			Control (n = 494)					
	Baseline	Follow up	Diff.	Baseline	Follow up	Diff.	*t*	*p*	*d* [95% CI]
Intention-to-treat analysis									
RSOD frequency, preceding 30 days	0.76 (1.21)	0.69 (0.99)	-0.07	0.68 (1.10)	0.73 (1.05)	0.05	1.31	.19	0.10 [-0.02, 0.23]
Number of standard drinks in a typical week	5.47 (8.43)	4.53 (6.21)	-0.94	4.78 (6.92)	4.41 (5.87)	-0.37	0.55	.58	0.08 [-0.04, 0.20]
Estimated peak blood alcohol concentration	1.10 (1.08)	0.96 (0.93)	-0.14	1.02 (1.08)	0.99 (0.98)	-0.03	1.42	.16	0.12 [0.00, 0.24]
Complete-cases analysis									
RSOD frequency, preceding 30 days	0.74 (1.22)	0.67 (1.02)	-0.07	0.67 (1.14)	0.71 (1.09)	0.04	1.53	.13	0.12 [-0.01, 0.25]
Number of standard drinks in a typical week	5.27 (7.91)	4.59 (6.61)	-0.68	4.70 (6.90)	4.39 (6.11)	-0.31	0.54	.59	0.06 [-0.06, 0.19]
Estimated peak blood alcohol concentration	1.63 (1.78)	0.96 (0.96)	-0.67	1.48 (1.42)	0.99 (1.02)	-0.49	1.42	.16	0.13 [0.01, 0.26]

Linear mixed models with group as a fixed factor; school classes as the random intercept; differences from baseline to follow-up as outcomes; and baseline scores, smoking status, educational level and misperception of quantity of peer alcohol consumption at baseline as covariates. d = Cohen's d. RSOD: risky single-occasion drinking

Ancillary Subgroup Analysis

Results stratified according to risk group (low, medium, high) are summarized in Tables 6 and 7. The results of the ITT analysis examining RSOD prevalence by risk group are displayed in Figure 4. With regard to their statistical significance, the results of the ITT subgroup analyses did not differ from those of the CC analyses. Group effects were detected exclusively for participants for whom baseline assessment indicated that they were at high risk of problematic alcohol use, which was defined as > 2 RSOD occasions during the 30 days preceding baseline assessment.

Within this high-risk group, RSOD prevalence decreased by 23.7% (from 100% to 76.3%) in the intervention group and 8.1% (from 100% to 91.9%) in the control group (OR = 0.29, p = .047) relative to that observed at baseline. Frequency of RSOD in the preceding 30 days decreased by 1.48 in the intervention group and 0.86 in the control group (Cohen`s d = 0.34, p = .01), and estimated peak blood alcohol concentration decreased by 0.58 in the intervention group and 0.14 in the control group (Cohen`s d = 0.38, p = .03).

Table 6. Intervention effects for dichotomous outcomes according to baseline drinking risk group (intention to treat analysis)

	Intervention (n = 547)			Control (n = 494)					
	Baseline	Follow up	Diff.	Baseline	Follow up	Diff.	*z*	*p*	OR [95% CI]
RSOD, preceding 30 days									
Low risk	0 (0.0%)	48 (16.8%)	16.8%	0 (0.0%)	59 (21.2%)	21.2%	-1.959	.051	0.64 [0.41, 1.00]
Medium risk	179 (98.9%)	117 (64.6%)	-34.3%	137 (96.5%)	97 (68.3%)	-28.2%	-0.97	.33	0.76 [0.44, 1.31]
High risk	80 (100.0%)	61 (76.3%)	-23.7%	74 (100.0%)	68 (91.9%)	-8.1%	-1.99	.047	0.29 [0.09, 0.98]
Overestimation of peer drinking norms									
Low risk	122 (42.7%)	128 (44.8%)	2.1%	112 (40.3%)	109(39.2%)	-1.1%	1.06	.29	1.24 [0.83, 1.84]
Medium risk	83 (45.9%)	76 (41.9%)	-4.0%	52 (36.6%)	58 (40.8%)	4.2%	-0.12	.91	0.97 [0.58, 1.64]
High risk	35 (43.8%)	30 (37.5%)	-6.3%	39 (52.7%)	32 (43.2%)	-9.5%	-0.46	.64	0.84 [0.40, 1.76]

Logistic generalized linear mixed models with group as a fixed factor; school classes as the random intercept; follow-up values as outcomes; and baseline scores, smoking status, educational level and misperception of quantity of peer alcohol consumption at baseline as covariates. RSOD: risky single-occasion drinking

Table 7. Intervention effects for continuous outcomes according to baseline drinking risk group (intention to treat analysis)

	Intervention (n = 547)			Control (n = 494)					
	Baseline	Follow up	Diff.	Baseline	Follow up	Diff.	*t*	*p*	*d* [95% CI]
RSOD frequency, preceding 30 days									
Low risk	0 (0.0)	0.25 (0.52)	0.25	0 (0.0)	0.29 (0.78)	0.29	-0.77	.44	0.06 [-0.11, 0.23]
Medium risk	0.98 (0.39)	1.03 (1.05)	0.05	0.89 (0.39)	0.95 (0.79)	0.06	1.01	.31	0.02 [-0.20, 0.24]
High risk	2.99 (1.57)	1.51 (1.30)	-1.48	2.81(1.15)	1.95 (1.26)	-0.86	2.59	.01	0.34 [0.02, 0.66]
Number of standard drinks in a typical week									
Low risk	0.98 (1.72)	2.01 (3.55)	1.03	1.09 (1.84)	2.01 (3.82)	0.92	-0.21	.83	-0.03 [-0.20, 0.13]
Medium risk	7.08 (6.92)	6.14 (6.22)	-0.94	6.65 (5.54)	5.39 (4.18)	-1.26	-0.99	.33	-0.04 [-0.26, 0.18]
High risk	17.85 (11.71)	9.90 (8.63)	-7.95	15.07 (9.24)	11.53 (8.24)	-3.54	1.62	.11	0.37 [0.05, 0.68]
Estimated peak blood alcohol concentration									
Low risk	0.27 (0.31)	0.48 (0.56)	0.21	0.27 (0.30)	0.53 (0.69)	0.26	0.91	.37	0.08 [-0.09, 0.25]
Medium risk	1.91 (0.89)	1.41 (0.94)	-0.50	1.86 (0.96)	1.33 (0.84)	-0.53	-0.42	.67	-0.03 [-0.25, 0.19]
High risk	2.24 (0.82)	1.66 (1.02)	-0.58	2.22 (0.91)	2.08 (1.03)	-0.14	2.18	.03	0.38 [0.06, 0.70]

Linear mixed models with study group as a fixed factor; school classes as the random intercept; differences from baseline to follow-up as outcomes; and baseline scores, smoking status, educational level and misperception of quantity of peer alcohol consumption at baseline as covariates. d = Cohen's d.
RSOD: risky single-occasion drinking

4.1.4 Discussion

This study aimed to determine the efficacy of a combined web- and text messaging-based intervention designed to reduce problem drinking in Swiss upper secondary and vocational school students. Four main findings were revealed: (1) the intervention approach reached the majority of students, with 3 out of 4 participating in the programme and associated study. (2) According to the ITT analysis, the intervention resulted in a significant reduction in RSOD prevalence relative to that observed in the control group. (3) Based on subgroup analysis, high-risk alcohol users characterized by at least 2 RSOD occasions within the preceding month benefited from the intervention. (4) Neither positive nor negative intervention effects were observed in the subgroup of students who were not at risk of alcohol use.

Similar to a previous pre-post study examining this intervention approach (Haug et al., 2013), 3 out of 4 students who were invited to participate in the programme and study agreed to do so. Given the 3-month duration of the programme and the requirement for provision of a mobile phone number, the participation rate was considered very high. The main reason for the high participation rate could have been a combination of the proactive nature of the invitations to participate received by school classes and the offer of an attractive, low-threshold mobile phone-based intervention. In a comparison of recent studies in which young people were recruited for web-based alcohol interventions irrespective of drinking level, a more reactive recruitment approach involving e-mail invitation revealed a participation rate of 37% in young Swiss men (Bertholet et al., 2015a); in addition, a study involving ninth-grade students from the US resulted in a participation rate of 52% (Doumas, Esp, Turrisi, Hausheer, & Cuffee, 2014). As reported in an accompanying paper on student accessibility to the MobileCoach Alcohol programme (Haug, Paz Castro, & Schaub, 2015), female sex, younger age, and a higher maximum number of standard drinks per occasion were associated with higher participation rates. Beyond participation, retention was also very good, and nearly all

participants remained logged in until the end of the programme, which could have occurred because most participants evaluated the number of text messages as appropriate.

The ITT but not the CC analysis showed a significant intervention effect for the total sample regarding the primary outcome (RSOD). This underlines the necessity and advantages of ITT analyses based on sophisticated imputation techniques (Van Buuren, 2012), which typically result in less biased estimates and have the advantage of using all available data, whereby sample size and statistical power are preserved. The main reason for a significant effect in the ITT analysis but not in the CC analysis might have been due to higher statistical power in the former analysis.

Within the subgroup characterized by initial high-risk alcohol consumption, both ITT and CC analysis showed a significant intervention effect for the main outcome. Although the subgroup analyses were underpowered for detecting differences at the conventional alpha level, the results suggest that particularly heavy drinkers benefited from the intervention, with reductions of 23.7% and 8.1% in RSOD prevalence in the intervention and control groups, respectively. The more pronounced intervention effect observed in heavy drinkers is consistent with the results of another recently published Swiss study, in which a web-based intervention exerted an effect in young men who reported unhealthy alcohol use (Bertholet et al., 2015b), but this effect was not observed in those who did not report unhealthy alcohol use (Bertholet et al., 2015a). Contrary to our findings, (Bertholet et al., 2015a) reported significant intervention effects on number of drinks consumed per week, with no effect observed on RSOD prevalence. A possible explanation for this is that our text messages were designed to reduce RSOD, and some were sent on individually indicated typical drinking days and times.

With respect to the potential iatrogenic effects (Werch & Owen, 2002) of web-based alcohol interventions, the results of the subgroup analyses underlined those of recently published studies (Bertholet et al., 2015b; Prince, Reid, Carey, & Neighbors, 2014) in which normative

feedback did not lead to a stronger increase in drinking in those who did not report problem drinking, compared to control group participants. Rather, a protective effect of the intervention might be assumed as 21.2% of the initial low risk control group participants but only 16.8% of the initial low risk intervention group participants showed RSOD at follow up. Considering that the subgroup analyses were underpowered and showed no significant effect but a tendency towards a protective effect on the main outcome, further adequately powered studies should be conducted to determine efficacy in low and medium risk drinkers. Furthermore, studies should be conducted to compare the efficacy of substance-related intervention concepts, such as normative feedback, and more general skills-based interventions, which are promising in this subgroup of low risk drinkers (Spoth, Greenberg, & Turrisi, 2008).

Although the pooled results of previous studies on web- and computer-based personalized normative feedback interventions have shown a significant effect on perceived peer drinking norms (Foxcroft et al., 2015), we did not find such an intervention effect. This might be due to the combination of intervention elements derived from different theoretical approaches. Only the web-based part of the intervention provided normative feedback and the text messaging-based part of the intervention primarily addressed outcome expectations, motivation to drink within low-risk limits, self-efficacy, and planning processes. Comprehensive mediation analyses on the mechanisms through which behavioural change occurred will be presented in an upcoming article.

The main limitation of the current study was its reliance on self-report and the associated possibility that results may have been influenced by social desirability. Measures used to avoid under- or over-reporting of alcohol consumption included assurance of confidentiality and anonymous assessments conducted via tablet computers and without personal contact, which may have increased the reliability of self-reported data. Another limitation is the lack

of stratification of the sample by drinking status prior to random assignment. Although tests for baseline differences on RSOD prevalence and drinking risk group were not significant and we controlled for baseline values within the models, it is possible that the apparent intervention effect or some portion of it was attributable to regression to the mean.

Further limitations included that the effects of the intervention could not be attributed to the web-based part or the text messaging part or their combination, a relatively short follow-up period, with only one assessment 6 months subsequent to baseline assessment, the lack of a measure of harm associated with RSOD, and limited generalizability because of the inclusion of a convenience sample of school classes willing to participate in the study.

In conclusion, the MobileCoach Alcohol programme, a combined web- and text messaging-based intervention, was effective in reducing RSOD prevalence in Swiss upper secondary and vocational school students. Subgroup analyses revealed intervention effects in high risk alcohol users, who also showed beneficial effects including reductions in RSOD frequency and estimated peak blood alcohol concentration. The intervention could be provided to adolescents irrespective of their drinking level because the provision of an individualized primary prevention intervention has several advantages over secondary prevention interventions and because not only problem drinkers seem to benefit from such a program (a tendency towards a protective effect was also found in the low risk drinking group). However, further adequately powered studies are required to determine efficacy in low- and medium-risk drinkers. Due to the high participation rate and the possibility to provide this intervention at relatively low costs, the program provides a viable mean to reduce RSOD for large groups of students within the school setting.

4.2 Moderators of outcome in a technology-based intervention to prevent and reduce problem drinking among adolescents[6]

4.2.1 Introduction

Alcohol use is an important public health issue worldwide (World Health Organization, 2014). In Switzerland, 17% of the population and 41% of young adults ages 20-24 years exhibit at least problematic alcohol use (Gmel et al., 2016), and heavy drinking remains the leading cause of mortality and morbidity in adolescence and early adulthood (Marmet et al., 2014). Technology-based alcohol interventions have been shown to be efficacious at reducing short-term risky alcohol use and alcohol-related problems in adolescents (O'Rourke, Humphris, & Baldacchino, 2016; Patton et al., 2014), but reviews also underline the unknown generalizability of current findings, since most studies have been conducted on student populations (Danielsson et al., 2014; Donoghue et al., 2014; White et al., 2010).

Alcohol interventions that are delivered via text messaging on mobile phones have only recently been developed and implemented successfully. This approach is widely accepted by adolescents with different educational levels, migration background and risk profiles of drinking and is easily implementable in this target group (Bock et al., 2016; Haug et al., 2016; Suffoletto et al., 2015; Suffoletto, 2016). Despite this evidence, intervention effects tend to be small and past research emphasizes the need for well-powered studies that analyse moderators of efficacy and make clear indications of which adolescents may benefit from such interventions (Mason et al., 2015; Patton et al., 2014).

In the past decade, moderators have been examined in the context of face-to-face and electronically-delivered brief alcohol interventions and range from development-related

[6] For a similar version of this chapter see Paz Castro, R., Haug, S., Kowatsch, T., Filler, A., Schaub, M. P. (2017). Moderators of outcome in a technology-based intervention to prevent and reduce problem drinking among adolescents. *Addictive Behaviors, 72*:64-71.

variables — like a person's family history of alcohol use (LaBrie, Feres, Kenney, & Lac, 2009) and age of drinking onset (Mallett et al., 2010) — to socio-demographic and socio-cognitive individual differences — like gender (Grossbard et al., 2016) and age (Henson, Pearson, & Carey, 2015), self-regulation (Carey, Henson, Carey, & Maisto, 2007), depression (Merrill, Reid, Carey, & Carey, 2014) and estimation of drinking norms (Bertholet et al., 2016).

In summary, interventions have thus far been found to be more effective for students with a self-reported family history of alcohol abuse (LaBrie et al., 2009) and among students with an early onset of drinking (Mallett et al., 2010). Some interventions have generated greater effects among male students (Grossbard et al., 2016; Henson et al., 2015), while others demonstrated greater effects among female students (Chiauzzi, Green, Lord, Thum, & Goldstein, 2005; LaBrie et al., 2009). In a study by Merrill et al. (2014), the intervention's effect depended on the interaction between gender and levels of depression, with the intervention being more effective in female students with low levels of depression. In contrast, high levels of depression moderated the effect among male students. Age moderated interventions success in Henson et al.'s (2015) study, were older students responded better to the intervention compared to freshmen. In another study, the intervention's effect was enhanced by greater self-regulation skills (Carey et al., 2007). One of the most recent studies that addressed a non-student population (Bertholet et al., 2016) found the intervention's effect to be greatest among males who overestimated drinking by others. In addition to these moderators, existing research has also demonstrated that students with higher severity of alcohol use at baseline responded better to brief alcohol interventions (Walters & Neighbors, 2005). Most of the above-mentioned studies are limited insofar as they only considered few moderators. Concurrently including multiple moderators in the statistical model allows addressing the question of which moderators are most important.

In the present study, we examined potential moderators of an automated web- and text messaging-based intervention that has previously been shown to be effective at reducing binge drinking prevalence in young people in Switzerland (Haug, 2016). The intervention aimed to have adolescents with lower-risk drinking patterns maintain drinking within low-risk limits, and adolescents with higher-risk drinking patterns reduce their problematic alcohol use. Based on (Gmel et al., 2011; National Institutes of Health, 2015) adolescents where assigned to the lower-risk drinking group if they showed no binge drinking during the preceding 30 days to baseline assessment and consumed <14 (7 for female students) standard drinks during a typical week.

Candidate moderators were selected based on theoretical considerations, previous research and influencing factors specific to our intervention. Candidate socio-demographic moderators were gender, age, immigration background, and educational background. Gender and age were included based on their relevance in previous research (Chiauzzi et al., 2005; LaBrie et al., 2009; Henson et al., 2015; Grossbard et al., 2016). Although the intervention was designed to be suitable for adolescents with different immigration and educational backgrounds (Haug, Kowatsch, et al., 2014), it cannot be guaranteed that the contents of the web- or text messaging-based intervention is similarly attractive and comprehendible for participants with different backgrounds. This exploration appeared relevant, since other studies had a rather homogeneous sample with respect to these characteristics (e.g. Chiauzzi et al., 2005; Turrisi et al., 2009; Henson et al., 2015).

Included health-related moderators were body-mass-index (BMI), drinking-risk group and smoking status. The intervention also aimed to foster lower-risk alcohol use in adolescents by highlighting the effects of alcohol consumption on weight. Thus, the interaction between BMI and treatment was examined. Similar to a previous study (Blow et al., 2009), drinking risk group was included as an indicator for severity of baseline alcohol use – a moderator that has been discussed previously (Walters & Neighbors, 2005). The moderating effect of smoking

status was explored based on previous findings that showed that alcohol use inversely moderated the effect of a text messaging-based intervention that aimed to reduce tobacco use (Haug, Schaub, Venzin, Meyer, & John, 2013a).

Selected socio-cognitive moderators were social drinking norms and self-efficacy. Although drinking norms are hypothesized to increase pressure to drink among adolescents (Perkins, 2003), previous studies showed inconclusive results about its moderating effect on alcohol interventions (Bertholet et al., 2016; Grossbard et al., 2016). Self-efficacy is a central component of various health behaviour theories (Rogers, 1983; Bandura, 1986; Prochaska & DiClemente, 2005; Schwarzer, 2008) that overall postulate a greater influence of interventions in people with higher self-efficacy. Although the perceived drinking norm has been identified as important mediator previously (Reid & Carey, 2015a) and self-efficacy is supposed to be a promising mediator (Reid & Carey, 2015a), the present study sought to explore whether baseline levels of these two factors could predict response to a web- and text messaging-based intervention. Although these analyses were designed to be exploratory, a few specific hypotheses were postulated. We expected older participants, participants within the higher-risk drinking group and participants with higher levels of self-efficacy to have better outcomes. We did not have specific hypotheses about the other variables. We also did not expect some moderators to be more influential than others in our multivariate analyses.

In addition to evaluating moderators of outcome across the entire sample of subjects, we also assessed these two subject subgroups separately. In doing so, different indications with respect to drinking risk profiles may be drawn for technology-based interventions.

4.2.2 Methods

Study design

Data for this study were derived from a two-arm, parallel-group, cluster-randomised controlled trial that used school class as the randomisation unit, as detailed elsewhere (Haug

et al., 2016; Haug, Kowatsch, et al., 2014). Students in vocational and upper secondary schools in Switzerland were invited, irrespective of their level of alcohol use, to participate in the technology-based program called *MobileCoach Alcohol.* This program combined the advantages of two communication channels – comprehensive pictographic web-based feedback right after completion of the baseline assessment and individually-tailored text messages, provided over a period of three months, some of which were sent at individually-indicated typical drinking times. The web-based feedback was based on the social norms approach (Perkins, 2003), while the text messages included elements of Social Cognitive Theory (Bandura, 2004; McAlister et al., 2008), such as: (1) positive outcome expectancies to drink within low-risk limits; (2) self-efficacy to resist social pressures to drink; and (3) planning processes to translate intentions to resist alcohol into action. Based upon their self-reported baseline drinking patterns, participants were determined to be either at lower or higher risk of problematic alcohol use. Text messages for the lower-risk group focused on (a) motivation for drinking within low-risk limits; and (b) strategies to resist alcohol in different drinking situations. Text messages for the higher-risk group focused on (a) motivation to drink within low-risk limits; (b) alcohol-related problems; (c) estimated peak blood alcohol concentrations and related risk; and (d) strategies to resist alcohol in different drinking situations. Text messages concerning the last-mentioned category were sent on individually-indicated typical drinking days and times.

In the original study, binge drinking prevalence was found to decrease by 5.9% in the intervention group and to increase by 2.6% in the control group, relative to the baseline assessment (odds ratio [OR] = 0.62, 95% confidence interval [CI] = 0.44 –0.87). Subgroup analyses revealed that higher-risk alcohol consumers benefitted most from the intervention, experiencing more pronounced reductions in binge-drinking prevalence, binge-drinking frequency, and peak blood alcohol concentration. The intervention was designed with and triggered by the open source behavioural intervention platform MobileCoach version 1.1

(Filler et al., 2015). The original study protocol was approved by the ethics committee of the Faculty of Philosophy at the University of Zurich, Switzerland (date of approval: 24 June, 2014). The study was registered at Current Controlled Trials ISRCTN (59944705, assigned 10 July 2014) and executed in full compliance with the Declaration of Helsinki.

Participants and recruitment

Participants were 1'041 students from 80 Swiss vocational and upper secondary school classes randomly assigned to either the web- and text message-based program MobileCoach Alcohol or to an assessment only control condition. At 6-month follow up, 966 (92.8%) students provided complete data on alcohol-related variables.

Moderators

Participants took part in an online health survey during a regular class session, by which data on potential moderators and outcome variables were collected. Socio-demographic characteristics that were assessed as potential moderators were gender, age, immigration background, and level of educational attainment of participants. We assessed countries of birth in students' parents to identify any potential immigrant background. Based upon this information, participants were assigned to one of the following categories: (1) neither parent born outside Switzerland; (2) one parent born outside Switzerland; or (3) both parents born outside Switzerland. In the analysis, we grouped subjects with either a one- or two-sided immigrant background into a single category for comparison against non-immigrants. The following common levels of educational attainment in Switzerland were assessed: (1) secondary school, (2) vocational school, and (3) technical/high school or university. For further analysis, we collapsed vocational school and technical/high school or university into a higher educational level, while secondary school was coded as a lower educational level.

Health-related characteristics that were investigated as potential moderators included body-mass-index (BMI) and tobacco smoking. Tobacco smoking was assessed using the following question: 'Do you currently smoke cigarettes or have you smoked in the past?' with the following available response options: (1) I smoke cigarettes daily; (2) I smoke cigarettes occasionally, but not daily; (3) I smoked cigarettes in the past, but do not smoke anymore; and (4) I have never smoked cigarettes or have smoked less than 100 cigarettes throughout my entire life. For analysis, we collapsed daily baseline smoking and occasional smoking into a single category for comparison against baseline non-smokers.

Socio-cognitive characteristics that were assessed as potential moderators were peer-drinking norms and self-efficacy. Estimates of peer-drinking norms were derived using items extracted from Haug et al. (2011), who used modified versions of the first and second consumption items of the Alcohol Use Disorders Identification Test (Bradley et al., 2007): 'How often does a typical (male/female) adolescent at the age of (xx years) have a drink containing alcohol?' and 'How many drinks does a typical (male/female) adolescent at the age of (xx years) years have on a typical day when drinking alcohol?' Self-efficacy for refraining from alcohol use was assessed via the item: 'I am confident that I can abstain from alcohol use over the next month', with response options ranging from 0 'not at all confident' through 5 'very confident'.

Primary outcome

The primary outcome of interest was binge-drinking prevalence over the preceding 30 days, which comprised the percentage of subjects who reported at least one episode of binge drinking. Binge-drinking prevalence was assessed by asking participants to report the number of standard drinks they consumed on their heaviest drinking occasion over the preceding 30 days. Pictures of standard drinks containing 12–14 grams of ethanol were provided for beer, wine, spirits, alcopops and cocktails, along with conversion values (e.g., three 0.5 litre cans of

beer = 6 standard drinks). Binge drinking was defined as drinking at least five drinks on a single occasion for men, and at least four drinks on a single occasion for women (Gmel et al., 2011). This assessment was performed both at baseline and 6-month follow up.

Statistical analysis

Details of outcome analysis and missing data imputation procedures are provided in Haug et al. (2016). All moderator analyses reported herein were performed on an intent-to-treat basis to identify associations between various socio-demographic, health-related and socio-cognitive characteristics measured at baseline and the outcome of interest at six months of follow up in the intervention versus control group, controlling for baseline values of the outcome. Analyses were conducted both across the overall sample and separately in two subgroups categorized as lower versus higher-risk alcohol consumption.

Generalized linear mixed models were tested specifying a single random effect for class (random intercept). For the detection of potential moderators, we adopted a hierarchical backward stepwise approach, similar to that described elsewhere (Carey et al., 2007). This analysis evaluated for the amount of change in the Akaike information criterion (AIC) statistic deleting each given independent variable to identify the most parsimonious model. Variables were retained if the change in the AIC statistic was > 2 points. The baseline model for each outcome initially contained the group main effect, the 11 moderator main effects, and the 11 group-by-moderator interactions. The analysis was conducted in two stages, beginning with an evaluation of two-way interactions, followed by the main effects only. Any effects involved in an interaction retained by the backward stepwise procedure were not subject to removal during the subsequent stage. Finally, the group main effect was retained, irrespective of its influence on the AIC statistic, to reflect the experimental design. Since the detection of moderator effects in field studies is less efficient due to increased measurement error (McClelland & Judd, 1993), all effects in the final model were assessed at the $p < .10$ level.

Analyses were performed using the software statistical packages SPSS version 22 and R version 3.3.0 via lme4 (Bates et al., 2014).

4.2.3 Results

Sample characteristics

Baseline characteristics for the study sample are shown in Table 8. Among the 547 subjects assigned to active treatment, 51.7% were female, versus 53.6% females in the 494 controls. Participants averaged 16.9 years of age (SD = 1.6). Baseline differences between the intervention and control group were detected for smoking status, with a significantly higher proportion of smokers in the intervention group ($\chi 2 = 8.9$, $p < .01$).

Table 8. Baseline characteristics of the study 2 sample. Values represent n (%) unless stated otherwise.

Variable	Intervention *n* = 547	Control *n* = 494	Total *N* = 1'041	*p* [a]
Sex				.49[b]
Male	264 (48.3%)	229 (46.4%)	493 (47.4%)	
Female	283 (51.7%)	265 (53.6%)	548 (52.6%)	
Age, *M (SD)*	16.9 (1.6)	16.8 (1.4)	16.8 (1.6)	.83[c]
Immigration background				.42[b]
No immigration background	320 (58.5%)	272 (55.1%)	592 (56.9%)	
One parent born outside Switzerland	117 (21.4%)	107 (21.7%)	224 (21.5%)	
Both parents born outside Switzerland	110 (20.1%)	115 (23.3%)	225 (21.6%)	
Education				.72[b]
Low	489 (89.4%)	445 (90.1%)	934 (89.7%)	
High	58 (10.6%)	49 (9.9%)	107 (10.3%)	

Body mass index, *M (SD)*	21.8 (9.5)	21.5 (7.4)	21.6 (8.5)	.50[c]
Tobacco smoking status				.003[b]
Non-smoker	395 (72.2%)	396 (80.2%)	791 (76.0%)	
Smoker	152 (27.8%)	98 (19.8%)	250 (24.0%)	
Binge drinking, preceding 30 days				.14[b]
No	289 (52.8%)	283 (57.3%)	572 (54.9%)	
Yes	258 (47.2%)	211 (42.7%)	469 (45.1%)	
Number of standard drinks consumed in a typical week in the preceding 30 days, *M (SD)*	5.5 (8.4)	4.8 (6.9)	5.1 (7.8)	.52[d]
Drinking risk group				.19[b]
Low	286 (52.3%)	278 (56.3%)	564 (54.2%)	
High	261 (47.7%)	216 (43.7%)	477 (45.8%)	

[a] *p* values for the comparison of the intervention and control groups, [b] χ^2 test, [c] *t* test, [d] *U* test

Moderator analysis in the overall sample

Results of ITT analysis examining moderators of binge-drinking prevalence across the total sample are summarized in Table 9. Both smoking status and educational level were retained as moderating effects in the final model, with significant interactions detected between smoking status and study condition (OR= 0.23, CI= 0.19-0.9, $p < 0.05$) and between educational level and study condition (OR= 0.37, CI= 0.13-1.05, $p < 0.10$). The intervention was more effective at reducing binge-drinking prevalence in smokers than in non-smokers (Figure 5). In smokers, it decreased the percentage of subjects who binge drank from 77.0% to 58.6% (absolute difference 18.4%) versus 77.6% to 70.1% pre- to post-intervention binge drinking in smoking controls (absolute difference 7.5%). Meanwhile, among non-smokers, the intervention only reduced the percentage of binge drinkers from 35.8% to 34.2% (1.6%)

versus from 34.1% to 32.6% (1.5%) in non-smoking controls. Thus, the relative intervention effect was -10.9% in smokers versus -0.1% in non-smokers.

Similarly, the intervention was more effective in highly-educated versus less-educated subjects (Figure 6). In more highly-educated subjects, the percentage of binge-drinkers pre- to post- intervention fell from 54.4% to 34.5% (absolute difference 19.9%), with no decline at all noted in highly-educated controls. Meanwhile, in less-educated subjects, corresponding declines were from 46.4% to 41.7% (4.7%) and from 42.0% to 39.0% (3.0%), respectively. Thus, the relative intervention effect was -19.9% in highly-educated versus -1.7% in less-educated subjects.

Other variables exhibited a main effect on the binge-drinking prevalence and were retained as predictors in the final model. Older age (OR= 0.85, $p < 0.05$) and higher levels of self-efficacy (OR= 0.78, $p < 0.01$) at baseline were associated with lower binge-drinking prevalence at follow-up. A higher body-mass-index (BMI, OR= 1.09, $p < 0.01$) was associated with higher binge-drinking prevalence at follow-up.

Table 9. Moderators of binge drinking prevalence in the total sample and according to baseline drinking risk group.

	Overall sample (N= 1041)		Low at risk (n= 564)		At risk (n= 477)	
Variable	Odds Ratio (OR)	95% CI	OR	95% CI	OR	95% CI
Group	1.27	[0.83; 1.93]	1.66	[0.87; 3.15]	1.00	[0.63; 1.60]
Gender	--	--	--	--	0.64*	[0.41; 0.98]
Immigration	--	--	--	--	--	--
Education	1.48	[0.71; 3.12]	3.59*	[1.24; 10.44]	--	--
Age	0.85*	[0.75; 0.97]	0.75*	[0.61; 0.93]	--	--
BMI	1.09*	[1.03; 1.16]	1.12*	[1.03; 1.22]	--	--
Drinking risk group	--	--				
Smoking status	2.61**	[1.42; 4.82]	--	--	--	--
Perception of peer alcohol consumption						
Quantity	--	--	--	--	--	--
Frequency	--	--	--	--	--	--
Self-efficacy	0.78*	[0.67; 0.90]	--	--	0.75**	[0.62; 0.90]
Group x Gender	--	--	--	--	--	--
Group x Immigration	--	--	--	--	--	--
Group x Education	0.37†	[0.13; 1.05]	0.19†	[0.03; 1.02]	--	--
Group x Age	--	--	--	--	--	--
Group x BMI	--	--	--	--	--	--
Group x Drinking risk group	--	--				
Group x Smoking status	0.42*	[0.19; 0.90]	0.13**	[0.03; 0.57]	--	--
Group x Perception quantity	--	--	--	--	--	--
Group x Perception frequency	--	--	--	--	--	--
Group x Self-efficacy	--	--	--	--	--	--

Note. Odds ratio (OR) and 95% confidence intervals (CI) for all effects remaining in the final model. Dashes represent effects that were dropped from the respective final model in the total sample and in the ancillary analyses according to baseline drinking risk group. Group was coded as -0.5= control, 0.5= intervention. Gender was coded as 0= man, 1= female. Immigration was coded as 0= Swiss background, 1= Other background. Education was coded as 0=low, 1=high. Drinking risk group was coded as 0= low, 1= high. Smoking status was coded as 0= non-smoker, 1= smoker. All continuous variables were mean centered. $^{**}p < 0.01$. $^{*}p < 0.05$. $^{\dagger}p < 0.10$.

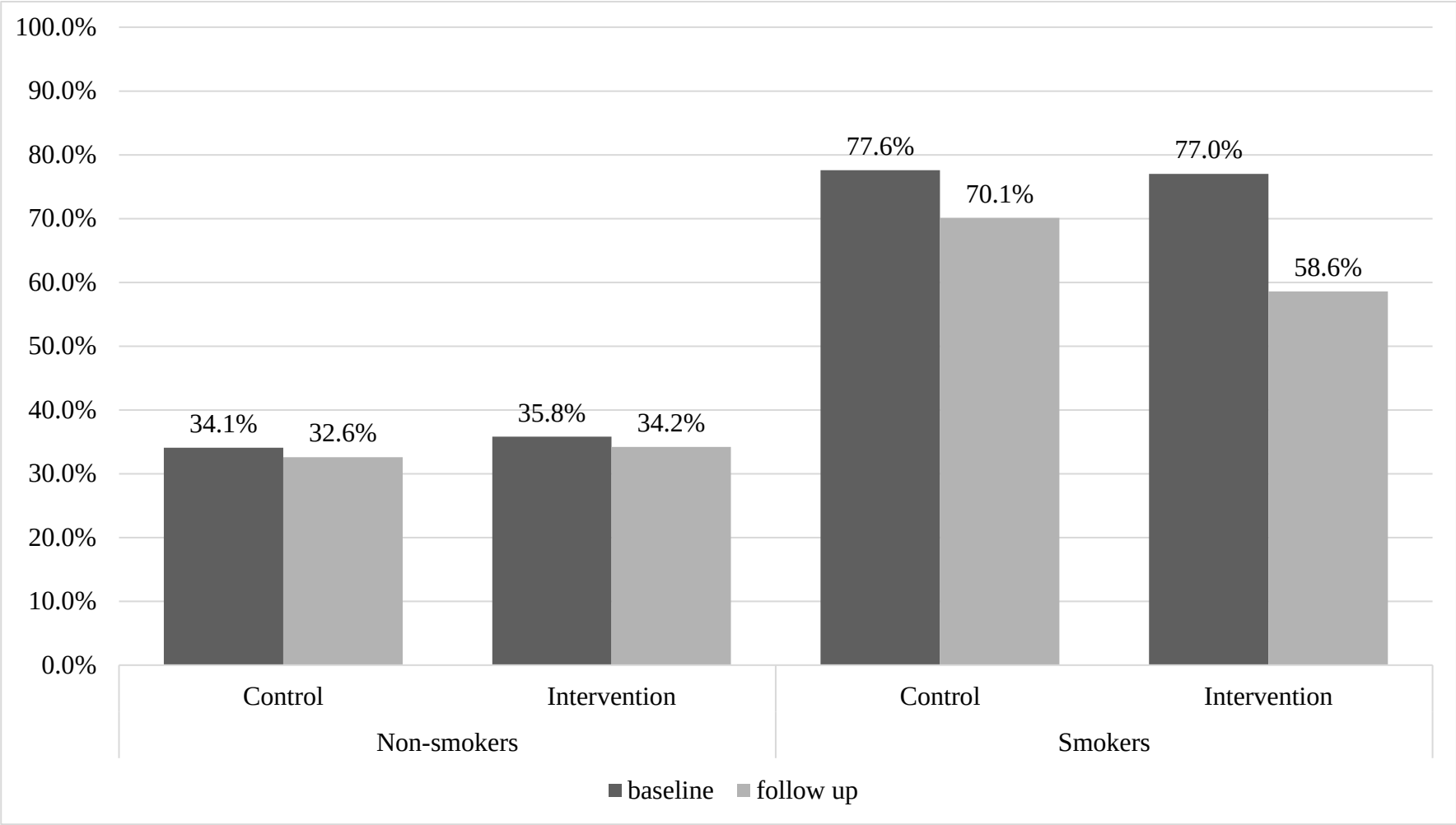

Figure 5. Percentage of binge-drinking prevalence by smoking status (non-smoker vs. smoker) and group condition in the total sample based on intention to treat analysis.

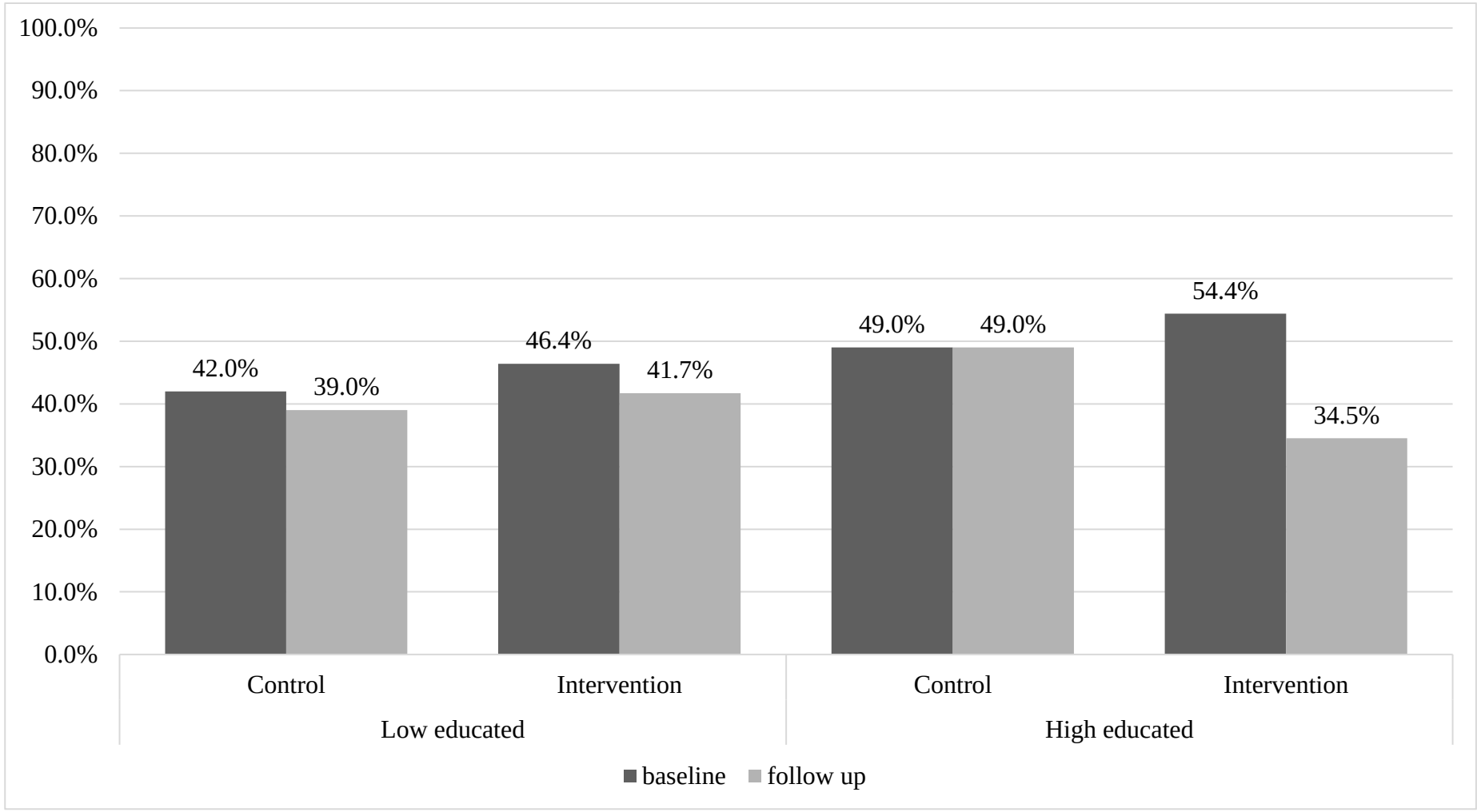

Figure 6. Percentage of binge-drinking prevalence by educational level (low vs. high) and group condition in the total sample based on intention to treat analysis.

Moderator analysis by drinking risk group

Results stratified by drinking risk group at baseline (lower versus higher risk) are summarized in Table 2. In the multivariate models, different main effects and interactions with binge-drinking prevalence were identified in the two baseline risk groups.

Within the lower-risk group, significant interactions between study condition and both smoking status (OR= 0.13, CI= 0.03-0.57, $p < 0.01$) and educational level (OR= 0.19, CI= 0.03-1.02, $p < 0.10$) were observed. The intervention was associated with less increase in binge-drinking prevalence in smokers than non-smokers (-32.4%, from 50.0% to 17.6%; versus +1.2%, from 14.7% to 15.9%), and in highly- (-27.5%, 40.0% to 12.5%) versus less-educated students (+0.9%, 16.0% to 16.9%); see Figures 7 and 8. Significant main effects were similar as in the total sample: Within lower-risk drinkers a higher BMI at baseline (OR= 1.12, $p < 0.05$) was associated with higher binge-drinking prevalence at follow-up, whereas older age (OR= 0.75, $p < 0.01$) was associated with lower binge-drinking prevalence at follow-up.

On the other hand, no significant moderating effects were apparent within the higher-risk group. Significant predictors of binge-drinking prevalence within this subgroup were gender and self-efficacy. Within higher-risk drinkers, being a female (OR= 0.64, $p < 0.05$) or showing higher levels of self-efficacy at baseline (OR= 0.75, $p < 0.01$) was associated with lower binge-drinking prevalence at follow-up.

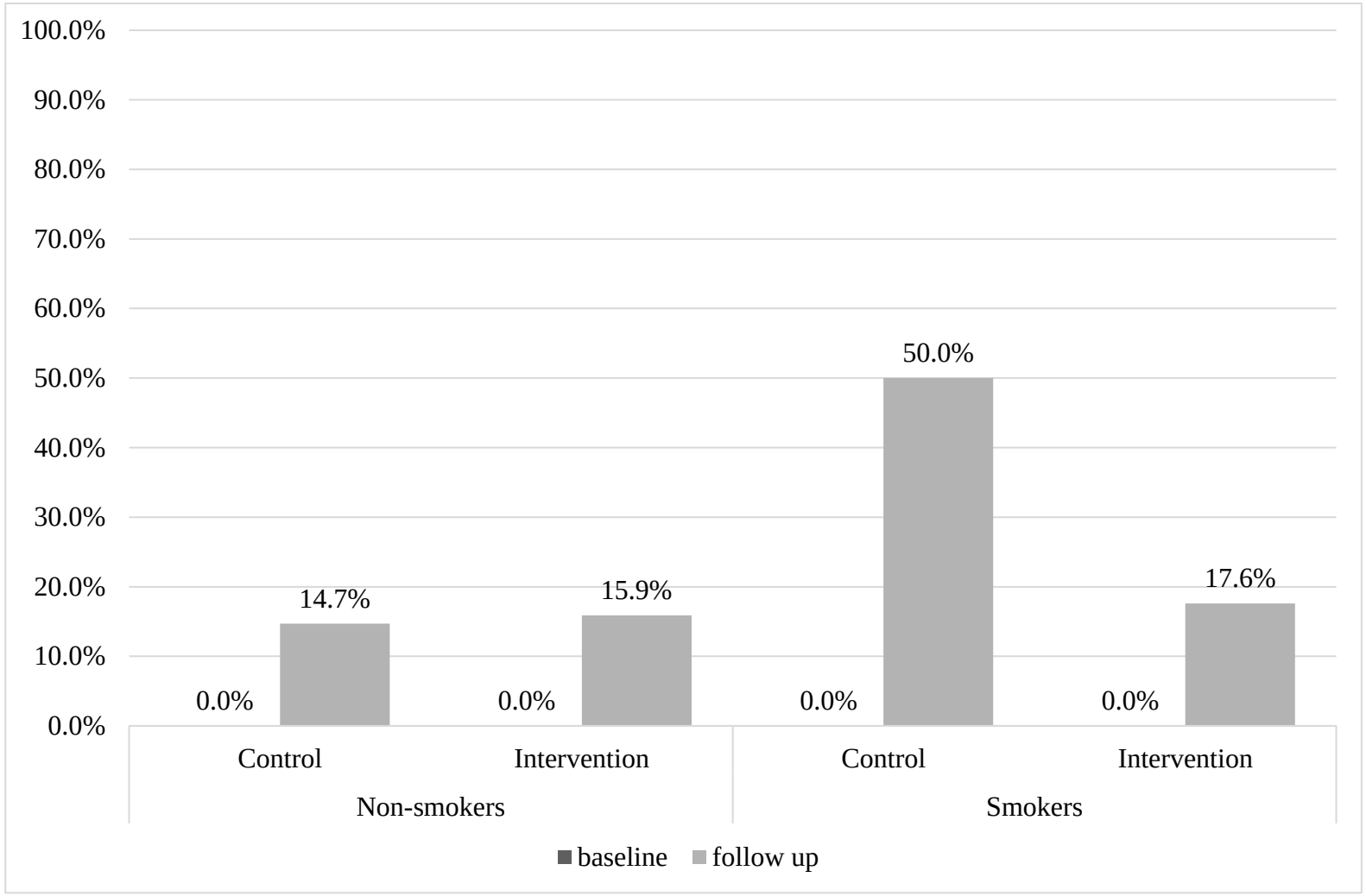

Figure 7. Percentage of binge-drinking prevalence by smoking status (non-smoker vs. smoker) and group condition in the lower-risk drinking subgroup based on intention to treat analysis.

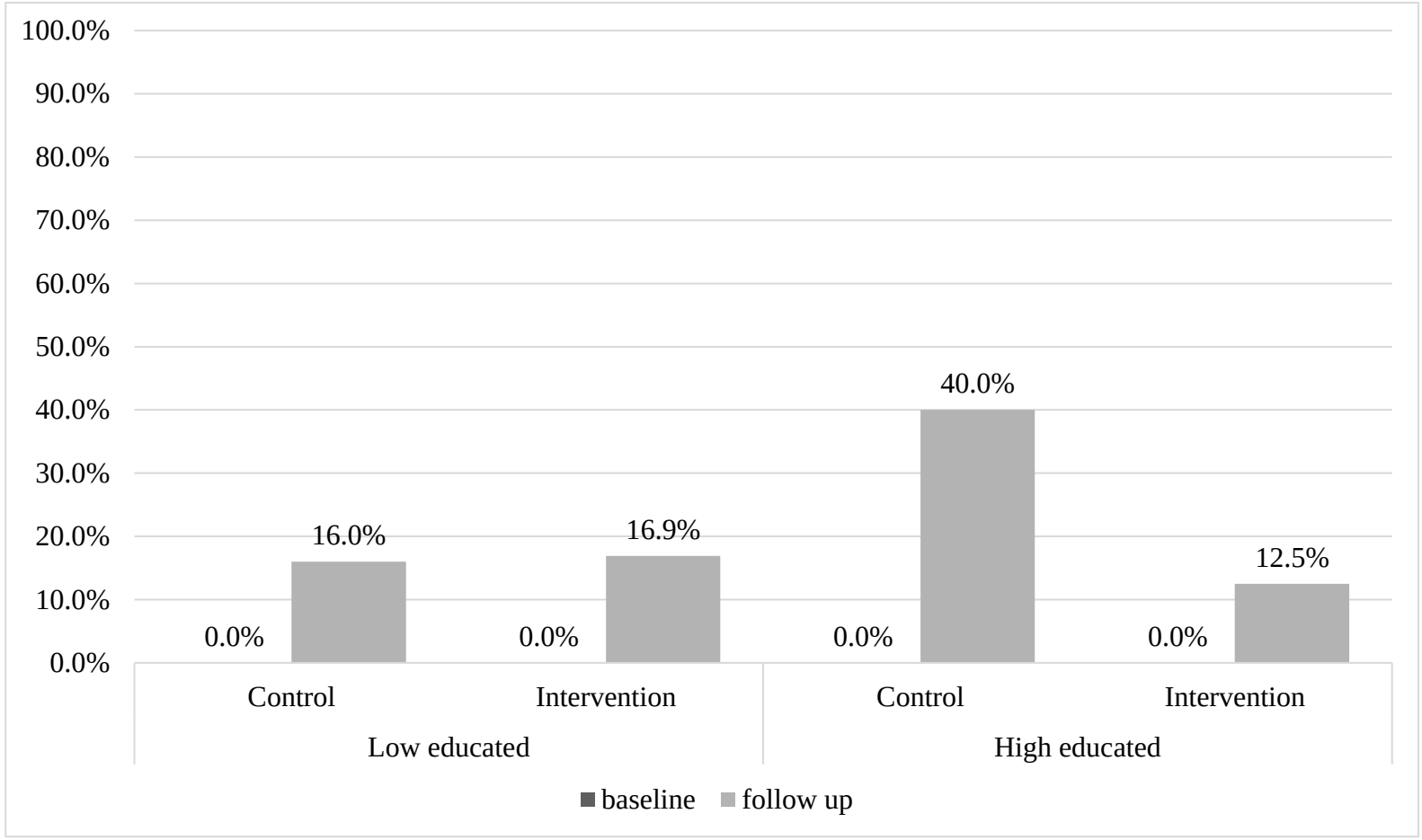

Figure 8. Percentage of binge-drinking prevalence by educational level (low vs. high) and group condition in the lower-risk drinking subgroup based on intention to treat analysis.

4.2.4 Discussion

In this study, we investigated socio-demographic, health-related, and socio-cognitive moderators of the effectiveness of a technology-based intervention designed to prevent or reduce binge drinking in adolescents. The three main findings were: (1) the intervention was more effective at reducing binge-drinking prevalence in smokers than in non-smokers; (2) the intervention also was more effective in highly- versus less-educated subjects; and (3) whereas smoking status and educational level were moderators of the intervention's effectiveness in subjects considered to be at lower risk for problem drinking, based upon their baseline level of alcohol use, no baseline characteristics moderated the intervention's effectiveness in higher-risk drinkers.

These findings highlight the moderating effect of smoking status on technology-based alcohol interventions designed to both reduce and prevent heavy drinking, a moderator that has even been neglected in studies that accounted for multiple moderators (Carey et al., 2007; Elliott, Carey, & Bolles, 2008; Henson et al., 2015). The present study indicates that smokers benefitted more from the technology-based intervention than non-smokers. Nevertheless, the binge-drinking prevalence was still higher among smokers relative to non-smokers at follow-up. Since alcohol and tobacco use often co-occur in adolescents (Haug, Schaub, Gross, John, & Meyer, 2013; McKee & Weinberger, 2013), future studies should investigate whether interventions targeting problematic alcohol use in this age group should be tailored to smoking status in order to improve the effectiveness of such programs. This is in line with implications of research that focused on face-to-face delivered treatment (Kay-Lambkin et al., 2013). In mobile-phone-based interventions, text messages with information about the relationship between alcohol and tobacco use could be sent at times when adolescents typically go out and the probability for using both substances is highest (Jiang & Ling, 2013). Two pilot studies have already investigated the inverse scenario. These studies included young adult smokers who regularly binge drink and demonstrated that tobacco abstinence

rates were higher among those who were allocated to an integrated intervention, targeting smoking cessation and binge-drinking reduction, compared to those who only received standard treatment for smoking cessation (Ames et al., 2010; Ames, Pokorny, Schroeder, Tan, & Werch, 2014a). To verify these findings, a two-arm, parallel-group, cluster-randomized controlled trial with assessments at baseline and six months follow-up is currently being conducted (Haug, Meyer, Dymalski, Lippke, & John, 2012).

More importantly, the present findings point out that technology-based alcohol interventions should be improved for non-smokers. Since adolescent non-smokers seem to be less influenced by peers for risk-taking in experimental studies (Cavalca et al., 2013), further efforts should be undertaken to understand the mechanism of risky alcohol use in non-smokers and potential reactivity to alcohol interventions in naturalistic settings. A possible explanation for binge drinking in adolescent non-smokers is that they overemphasize its relevance for bonding with peers while downplaying the detrimental effects of risky alcohol consumption on their health (Visser et al., 2013), especially since these effects are not as visible in everyday life as the consequences of tobacco smoking. On the basis of the recommendations of Visser et al. (2013), future studies should investigate if the effectiveness of technology-based alcohol interventions can be improved among non-smokers by emphasizing even more the effects of excessive alcohol use on young people's sociability, image and safety rather than focusing on health-related long- or short-term risks.

Further implications of our findings are that technology-based alcohol interventions should not only be directed towards higher-risk drinkers, who appear to experience the greatest reduction in heavy drinking (Haug et al., 2016), but also to lower-risk drinkers who smoke. Our findings suggest that technology-based alcohol interventions might help to counteract the well-documented association between tobacco use and increased risk for meeting criteria for problematic alcohol use in adolescents (McKee & Weinberger, 2013). In turn, practitioners should consider not delivering technology-based alcohol interventions to lower-risk drinkers

who do not smoke. Thereby, practitioners could refrain from providing superfluous information to adolescents who drink within low risk limits and do not smoke considering as their substance use pattern can be considered as being rather stable (McKee & Weinberger, 2013; Nelson, Ryzin, & Dishion, 2015). Instead, practitioners could start delivering technology-based interventions only when this patterns change remarkably.

In addition, our subjects who were more highly educated benefited more from the intervention than those with less education. To our knowledge, this is the first study documenting the moderating effect of educational level on a technology-based intervention, which can be due to the fact that previous studies were mostly conducted on college students (Carey et al., 2007; Elliott et al., 2008; Henson et al., 2015). Even if the intervention contained short messages and considerable graphical representation, further efforts might be beneficial to improve intervention effectiveness in less-educated adolescents. Recent research on less-educated, community college students (Bock et al., 2015, 2016) concluded that texts within technology-based interventions should emphasize the aspect of caring for harms related to adolescent's drinking behaviour. Future research is needed to establish whether interventional effects in this subgroup can be augmented either by simplifying the intervention or by otherwise adapting the contents.

No other socio-demographic characteristics besides educational level influenced the effectiveness of our intervention. More specifically, no moderating effects of age or gender were – contrary to previously-published research (Grossbard et al., 2016; Henson et al., 2015) – identified. Since our intervention was specifically tailored to gender and age, these results suggest that similar interventional effects might be observed in students with different socio-demographic characteristics other than educational level. Within the health-related moderators, BMI demonstrated to be predictive for binge-drinking prevalence, but did not interact with the success of the intervention. Interestingly, the moderating effect of the severity of alcohol use on alcohol interventions that was postulated in the review of Walters

and Neighbors (2005) was less important than the influence of smoking status in the current study. These findings have to be replicated in future studies. Also, no socio-cognitive moderators of the intervention's effectiveness were uncovered. Contrary to the study of Bertholet et al. (2016), baseline levels of perceived drinking norms did not moderate the efficacy of their technology-based intervention. Although the present study did examine the moderating effect of perceived quantity and frequency of peer drinking separately rather than the overall overestimation of drinking norms (Bertholet et al., 2016), our findings support the investigation of perceived drinking norm rather as a mediator (Reid & Carey, 2015a) than a moderator. Self-efficacy was retained in all analyses as a predictor of outcome rather than a moderator, which underlines its general relevance in behaviour change (e.g. Bandura, 2004; Schwarzer, 2008). Similar to drinking norms, future studies on technology-based interventions should investigate the mediating role of self-efficacy and add evidence to current inconclusive but promising findings (Reid & Carey, 2015a).

One main limitation of the current study is its reliance on self-report data and the associated possibility that the results may have been influenced by social desirability. Measures used to reduce the under- and over-reporting of alcohol consumption included the assurance of confidentiality and anonymous assessments conducted via tablet computers in the absence of any personal contact, which may have increased the reliability of self-reported data. Another limitation is that, although we accounted for the most often-implicated moderators of such programs, we may have overlooked other explanatory variables (e.g., the age of alcohol drinking onset, the degree of readiness-to-change). Another limitation is the lack of stratification of the sample by smoking status prior to random assignment; it is possible, for example, that the apparent moderating effect of smoking status is partly attributable to the higher proportion of smokers in the intervention group. However, previous studies (Carey et al., 2007; Elliott et al., 2008; Henson et al., 2015) on moderators of technology-based alcohol interventions failed to test for the influence of baseline differences in smoking status. Future

adequately balanced and powered studies on the impact of technology-based alcohol interventions among adolescent smokers are clearly needed.

In conclusion, the effect of the MobileCoach Alcohol program, a technology-based alcohol intervention, appears to be greater among smokers and more highly educated students. Particularly lower-risk drinkers who are more highly educated and smoke might be prevented from initiating heavy drinking through technology-based alcohol interventions. Further efforts are warranted to improve the effectiveness of such interventions in non-smokers and less-educated students.

4.3 Engagement within a mobile phone-based smoking cessation intervention for adolescents and its association with participant characteristics and outcomes[7]

4.3.1 Introduction

Tobacco smoking is one of the main contributors to the global burden of disease (Feigin et al., 2016). A survey of 15- and 16-year-old adolescents covering 36 European countries revealed that 21% considered themselves current smokers (Kraus, Guttormsson, Leifman, Arpa, & Molinaro, 2016). Since tobacco use often starts in adolescence, intervening before the development of a substance use disorder gains importance (Marsch & Borodovsky, 2016). Mobile phone-based programs for smoking cessation are promising tools for delivering treatment to large numbers of adolescents (Marsch & Borodovsky, 2016). Such programs have already been proven more effective than minimal or no intervention in adult smokers (Scott-Sheldon, Terry, Carey, Garey, & Carey, 2012; Head, Noar, Iannarino, & Grant

[7] For a similar version of this chapter see Paz Castro, R., Haug, S., Filler, A., Kowatsch, T., Schaub, M. P. (2017). Engagement within a mobile phone-based smoking cessation intervention for adolescents and its association with participant characteristics and outcomes. *Journal of Medical Internet Research, 19*(11). doi: http://dx.doi.org/10.2196/jmir.7928

Harrington, 2013; Mason et al., 2015; Spohr et al., 2015; Whittaker et al., 2016). While only trends towards the effectiveness of such programs in adolescents have been documented to date (Mason et al., 2015), studies highlight their acceptance by adolescent smokers with mixed intentions to quit smoking, and by adolescent smokers of different genders, educational levels, and immigrant backgrounds (Haug, Paz Castro, & Schaub, under review; Haug, Schaub, Venzin, Meyer, & John, 2013b).

Mobile phone-based smoking cessation programs are delivered via apps (Businelle et al., 2016) or text messaging (Borland et al., 2013; Haug, Schaub, Venzin, Meyer, & John, 2013b), with the greatest difference being the level of engagement demanded by the two approaches. The first demands that users proactively engage with the program, while the latter requires users to actively disengage from the program (Suffoletto, 2016). Engagement, for instance, has been conceptualised in previous studies both, as the usage or the subjective experience with the program (Perski et al., 2017). For text messaging-based programs, there is some evidence that the predominant engagers are female (Heminger, Boal, Zumer, & Abroms, 2016) and older, and that they exhibit lower rates of daily cigarette consumption (Christofferson, Hertzberg, Beckham, Dennis, & Hamlett-Berry, 2016); but none of these studies was conducted on adolescents.

User engagement with different smoking cessation programs has been linked to positive behavioural changes. With web-based interventions, for instance, higher numbers of visits and page views were associated with abstinence (Strecher et al., 2008; Schwarzer & Satow, 2012; Richardson et al., 2013). Recent studies on text messaging-based interventions point in the same direction. In a study by Balmford and Borland (2014), the efficacy of a text messaging-based smoking-cessation program was associated with completion of the program. Participants who elected to stop the program were less likely to be abstinent at follow-up. In another study by Heminger et al. (2016), rather than overall engagement, "post-quit" engagement and the use of specific program features, like pledges, were specifically

predictive of six-month abstinence. Even more accurately, a study by Christofferson et al. (2016) identified five different classes of user engagement, which in turn were associated with different levels of interventional success. These investigators extracted two classes of engagement (high engagement and increasing engagement) and three classes of disengagement (rapidly-decreasing engagement, delayed decreasing engagement, and low engagement), demonstrating that participants within the more engaged classes were significantly more likely to be abstinent at weeks 3, 4 and 5 than participants within less engaged classes.

However, there are also studies that question the association between high engagement and positive behaviour changes (Balmford & Borland, 2014; Businelle et al., 2016; Saul et al., 2016). For instance, Balmford and Borland (2014) found that users with the lowest text messaging-intensity had a greater chance of being abstinent at the one-month follow-up. The researchers concluded that users tend to be selective as to what they need, which is not to be confused with a lack of motivation. Furthermore, they questioned whether it would be of more help if greater engagement could be achieved among less responsive users. In another pilot study (Businelle et al., 2016) that investigated the use of an app-based smoking cessation program, the total number of actively-viewed Quit Tips and Medication Tips was predictive of non-abstinence at 12-week follow-up.

Three methodological issues make the contribution of a user's level of engagement to long-term abstinence somewhat uncertain: (1) Only one study has reported long-term outcome associations with engagement (Heminger et al., 2016). (2) Setting a quit-date and having a quit attempt is an integral component of most smoking-cessation programs (Schwarzer & Satow, 2012; Balmford & Borland, 2014; Businelle et al., 2016; Christofferson et al., 2016; Heminger et al., 2016). Such interventions are typically divided into pre-quit and post-quit phases. There is a lack of studies investigating engagement with a mobile phone-based intervention that was matched to stages of change and did not require subjects to set a quit

date. This is of special interest, since most adult and adolescent smokers do not report any serious intention to quit within the next month (Gmel et al., 2016; Haug, Schaub, Venzin, Meyer, & John, 2013b). (3) On the other hand, smokers who enroll in such cessation programs already tend to report an intention to quit smoking (Balmford & Borland, 2014; Christofferson et al., 2016; Heminger et al., 2016), which can lead to a self-selection of more engaged, and thus more successful subjects. To our knowledge, no studies have investigated engagement with a mobile phone-based cessation program in proactively-recruited smokers at different stages of change.

Thus, the current study aimed to examine trajectories of program engagement associated with long-term outcomes within a randomized controlled trial assessing a fully-automated, mobile phone-based program for young smokers that was based on the Health Action Process Approach (HAPA) stages of change model (Schwarzer, 2008). In this study, we conceptualised engagement as the usage of the program. We expected to find trajectories of higher and lower program engagement, similar to the study of Christofferson et al. (Christofferson et al., 2016). Compared to their study (Christofferson et al., 2016), we did not expect a concrete amount of trajectories, since we applied a different analysis method and our sample was not only constituted by participants intending to quit smoking. Factors that predict engagement and completion of the three-month program were analysed to sort out for whom such programs still need to be improved. We hypothesised that being female (Heminger et al., 2016), older age and smoking at lower daily rates (Christofferson et al., 2016) would predict engagement. In addition, this study investigated adolescents' engagement with different features of a mobile phone-based intervention, since identifying more and less influential components of such interventions has recently been raised as a means to help refine other health behaviour change programs (Ybarra, Prescott, & Holtrop, 2014).

4.3.2 Methods

Participants and Procedures

Data for this study were extracted from a two-arm, parallel-group, cluster-randomised controlled trial that used school class as the randomisation unit, as detailed elsewhere (Haug, Paz Castro, et al., 2014; Haug et al., under review). Students in vocational or upper secondary schools in Switzerland were invited to participate in a technology-based program called MobileCoach Tobacco if they (1) either smoked on a daily or occasional basis (at least 4 cigarettes in the preceding month and at least one cigarette during the preceding week), and (2) owned a mobile phone. Participating students were reimbursed 10 Swiss francs for participating in the baseline and follow-up assessments, and with 0.5 Swiss francs for each of the 11 text message assessments that they answered within the MobileCoach Tobacco program.

In the original trial, the efficacy of an integrated smoking cessation and alcohol intervention (MCT+) was tested against a smoking cessation only intervention (MCT) for smoking cessation in adolescents. A total of 1’471 students from 360 Swiss vocational school classes participated in this study. They were randomly assigned to either the combined program (MCT+, n= 730) or to the smoking cessation only program (MCT, n= 741). The original study found no significant difference between the programs in terms of reducing the number of cigarettes used per day (MCT+ vs. MCT: - 2.7 vs. -2.8), nor in increasing the 7-day point prevalence of smoking abstinence at follow-up (MCT+ vs. MCT: 14.9% vs. 14.0%).

The intervention was designed with, and triggered by, the open-source behavioural intervention platform MobileCoach version 1.1 (Filler et al., 2015). The original study protocol was approved by the ethics committee of the Faculty of Philosophy at the University of Zurich, Switzerland (date of approval: 24 June, 2014). The study was registered at Current Controlled Trials ISRCTN (ISRCTN02427446, assigned 8 September 2014) and executed in full compliance with the Declaration of Helsinki.

Description of MobileCoach Tobacco

The MCT+ program combined (1) tailored web-based feedback on individual drinking behaviours delivered directly after completion of the baseline assessment; (2) tailored mobile phone text messages to promote drinking within low-risk limits over a three-month period; (3) tailored mobile phone text messages to support smoking cessation for three months; and (4) the option of receiving twice daily strategies for smoking cessation centred around a self-defined quit-date. Only components (3) and (4) of the integrated intervention were delivered to participants in the MCT group. The theoretical backgrounds of these intervention components are described elsewhere (Haug et al., under review).

The web-based feedback, intended only for participants in the combined program, was provided immediately after completion of the baseline assessment. It included individually-tailored information (1) about calorie intake based on personal drinking data, and (2) age and gender-specific norms on the number of drinks consumed per week, as well as on the individual's frequency of binge drinking.

The alcohol-related text messages provided information on (1) strategies for drinking within low-risk limits, and (2) the association between smoking and alcohol consumption. These text messages were sent only to those subjects within the MCT+ condition who reported binge drinking previous to their baseline assessment, where binge-drinking is equivalent to the consumption of five or more drinks on a single occasion for men, and four or more drinks for women. These text messages were sent on Saturdays at 7 pm on even weeks, while on odd weeks they were sent at each particular individual's typical drinking day and time.

The tobacco-related text messages provided information relevant to each subject's individual HAPA stage of change (Schwarzer, 2008). Based on the HAPA stage (Schwarzer, 2008), subjects can be divided into 'pre-intenders' (individuals with no intention to quit smoking) and 'intenders' or 'actors' (individuals who seriously intend to quit smoking or have already quit). For pre-intenders, the text messages addressed the benefits of quitting, risks of smoking,

and methods for improving self-efficacy. For intenders, the text messages initiated planning processes; while for actors they emphasized self-regulatory skills.

During the three-month MobileCoach Tobacco program, participants in both intervention groups received one text message prompt per week that either assessed smoking-related target behaviours or encouraged the subject's participation in a quiz or message contest. These prompts were easily answered by typing a single letter, number, or sentence using the mobile phone's reply function. Every four weeks, smoking-related target behaviours, including the person's HAPA stage of change, were assessed through the question: 'Have you recently smoked cigarettes?', with the following response options (1) 'Yes, and I do not intend to quit' (pre-intender), (2) 'Yes, but I am considering quitting' (pre-intender), (3) 'Yes, but I seriously intend to quit' (intender), or (4) 'No, I have already quit smoking' (actor). Furthermore, among pre-intenders, the number of cigarettes smoked per day or week (depending on smoking status: daily/occasionally) was assessed every four weeks. For intenders and actors, the use of strategies to cope with craving, which were individually chosen within the baseline assessment, was assessed: e.g., 'Did you apply the following strategy recently? When I am at a party, I distract myself from smoking by dancing. Yes (Y) No (N)'.

Quizzes were included thrice during the MCT, with the questions targeting: (1) smoking norms (percentage of smokers within the same age- and gender-specific reference group); (2) the health consequences of smoking cessation (days until positive health consequences after smoking cessation); and (3) expenditures on cigarettes (money spent on cigarettes per year).

A contest that required participants to create a text message to motivate other participants to quit smoking (for non-intenders) or to provide concrete ways to help others quit smoking (for intenders and actors) was conducted twice during the intervention period. The best text message from each of the two categories, rated weekly by a tobacco cessation expert, was sent anonymously to participants in the respective categories after 48 hours.

Finally, additional text messages were offered to subjects who reported having the intention to quit smoking. Intenders and actors were informed biweekly about the option of receiving additional information around a chosen quit-date. After entering a scheduled quit date, the program provided up to two daily text messages on quit-day preparation and relapse prevention (weeks –1 to +1: two daily text messages; weeks +2 and +3: one daily text message).

Measures

Participants took part in an online health survey during a regular class session, by which data on potential predictors of engagement and outcome variables were collected. The socio-demographic characteristics that were assessed were gender, age, educational attainment, and immigrant background. The following common Swiss levels of educational attainment were assessed: (1) none, (2) secondary school, (3) extended secondary school, and (4) technical or high school. We assessed the country of birth of both parents of the students to identify any potential immigrant background. Based on this information, participants were assigned to one of the following categories: (1) neither parent born outside Switzerland, (2) one parent born outside Switzerland, or (3) both parents born outside Switzerland. For further analysis, we grouped subjects with either a one- or two-sided immigrant background into a single category for comparison against non-immigrants.

The health-related variables that were assessed were perceived stress, physical activity, body weight, typical number of drinks consumed per week, and whether any binge drinking had occurred in the month prior to the baseline assessment. Perceived stress was measured using the following single item: “In the last month, how severely have you felt stressed?” Participants were asked to indicate their response on a 6-point Likert scale that ranged from “not at all” to “very”. Self-reported moderate-to-vigorous physical activity (VPA) was measured by a question derived from the Health Behaviour in School Aged Children (HBSC)

study (Inchley et al., 2016): "Outside school, how many hours a week do you exercise or participate in sports that make you sweat or out of breath?" The typical number of drinks consumed weekly was assessed via a seven-day drinking calendar similar to the Daily Drinking Questionnaire (R. L. Collins et al., 1985), for which participants were asked to think about a typical week in the preceding month and record the number of standard drinks they typically consumed each day during that week. Examples of standard drinks containing 12–14 g of ethanol were provided for beer, wine, spirits, alcopops, and cocktails, along with conversion values (e.g., three 0.5 L cans of beer = 6 standard drinks). Binge drinking was assessed by asking participants to report the number of standard drinks they consumed on their heaviest drinking occasion over the preceding 30 days.

Tobacco smoking status was assessed using the question, "Are you currently smoking cigarettes?" with the following response options: (1) Yes - I smoke cigarettes daily; (2) Yes - I smoke cigarettes occasionally, but not daily; and (3) No. In occasional smokers, we assessed the number of days they typically smoked per month, the total number of cigarettes smoked within the previous seven days, and the number of cigarettes smoked on a typical smoking day. In daily smokers, we only assessed the mean number of cigarettes smoked per day. For occasional smokers, the average number of cigarettes smoked per day was computed by multiplying the typical number of smoking days per month with the number of cigarettes smoked on a typical smoking day, and dividing this product by 30.

Additionally, we assessed the following smoking-related variables: HAPA stage of change, and the number of previous quit attempts. Each subject's HAPA stage of change was assessed using the following question: "Have you recently smoked cigarettes?" with the following response options (1) "Yes, and I do not intend to quit" (Pre-intenders), (2) "Yes, but I am considering quitting" (Pre-intenders), and (3) "Yes, but I seriously intend to quit" (Intenders). Subjects were asked about their previous attempts to quit smoking with the question — "Have

you ever made a serious attempt to quit smoking?" — for which they were provided the response options "No", "Yes – once", and "Yes – more than once".

Engagement with the program was assessed in terms of the number of program participants who unsubscribed from the program (program attrition), the number of responses to the weekly text message prompts, the percentage of retrieved versus sent media objects within the program, and the number of smokers who entered a quit-date and activated the additional quit-day preparation program.

Smoking behaviour at six-month follow-up was assessed as the (1) 7-day point prevalence of smoking abstinence; and (2) the mean number of cigarettes smoked per day. To assess the 7-day point prevalence of smoking abstinence, subjects were asked to indicate whether they had taken a puff of a cigarette within the seven days previous to follow-up. The mean number of cigarettes smoked per day was assessed and computed in the same way as at the baseline assessment.

Statistical analyses

As a first step, we analysed whether persons who actively unsubscribed from the intervention differed from those who remained in the intervention, applying Pearson chi-square analysis to examine differences in categorical variables, and unpaired Student's t tests for continuous variables. Given that the combined intervention was more extensive, we also examined whether program attrition differed as a function of study condition. Participants who had either unsubscribed or did not receive the text messages, as seen from program log files, were excluded from further analysis. Then, we explored the use of different program features for the total sample and by treatment arm.

Subsequently, we examined engagement trajectories by analysing answers to weekly prompts, which were identical for both study groups. To this end, we performed sequence analysis using the TraMineR library (version 1.8-8) in R (Gabadinho, Ritschard, Mueller, & Studer,

2011). For each participant, answers to prompts (as described above) were ordered into a sequence of states (i.e., engagement trajectories). Similarities between participants' state sequences were computed using the optimal matching (OM) distance algorithm. OM is defined as the minimal effort, in terms of insertions, deletions and substitutions, of transforming one sequence into another. Homogeneous engagement trajectory groups (clusters) were then constructed from the distance matrix, using agglomerative nesting hierarchical clustering and Ward's linkage method. The number of clusters chosen was based on the highest relative loss of inertia (see function HCPC in FactoMineR package (Lê, Josse, & Husson, 2008)) and upon the quality of the clusters according to the average silhouette width (ASW, Studer, 2013). The ASW ranges from -1 to +1 and can be interpreted as the degree of coherence among assignments to clusters: a high degree of coherence (close to 1) indicates large between-group distances and strong within-group homogeneity.

Upon detecting different engagement trajectories, we examined for baseline differences between the clusters. Subsequently, we conducted multinomial logistic regression analysis to identify predictors of clusters characterized by lower engagement trajectories, compared to those with higher engagement trajectories. Initially, separate univariate multinomial logistic regression analyses were performed (subsequently referred to as univariate analyses) to evaluate potential predictors of engagement trajectories. After these univariate analyses, multivariate prediction models were developed. As suggested by Hosmer, Lemeshow, and Sturdivant (2013), variable selection consisted of the following steps: (1) Significant predictors ($p < .05$) identified during univariate analyses were entered into the preliminary multivariate model. (2) Variables that were non-significant at $p > .05$ were removed, one at a time, starting with those with the highest p-values (backward selection). (3) To account for suppressor effects, the resulting model was verified by adding the aforementioned excluded variables, separately, to the regression model. Only variables that were significant at $p < .05$ were retained in the final multinomial regression model (forward selection).

Finally, we compared smoking outcomes between participants grouped by their engagement trajectory. Since participants were nested in school classes, we conducted a generalized linear mixed model (GLMM) for the 7-day point prevalence of abstinence. For changes in consumed cigarettes per day, we conducted a linear mixed model (LMM). Engagement trajectory was included as an independent variable (fixed effect), and school class as a single random effect (random intercept). These analyses were conducted using the lme4 library (version 3.2.1) in R (Bates et al., 2014) on three statistical models due to the disparate reach of more engaged than less engaged participants at follow-up: (1) a complete-case dataset (CCA), (2) a last-observation-carried-forward (LOCF) dataset, and (3) an intention-to-treat dataset (ITT). Details of outcome analysis and missing data imputation procedures are provided in Haug et al. (under review). R version 3.3.3 was used to perform all sequence analyses and outcome analyses, while SPSS version 22 was used for all other analyses. All statistical tests were two-tailed, with $p < .05$ set as the criterion for statistical significance.

4.3.3 Results

Participants

Figure 9 depicts the progression of participants through the trial. Of the original 1471 study participants, 1418 (96.4%) completed the program. Those who failed to complete their intervention had either signed off (n= 31, 2.1%) or discontinued the intervention due to technical problems (n= 22, 1.5%). No significant baseline differences were observed between those who did and did not complete the intervention. Program attrition also did not differ between the two treatment arms, with 13 of the 741 (1.8%) participants in the MCT choosing to unsubscribe compared to 18 of the 730 (2.5%) assigned to the MCT+ ($\chi 2 = 0.90$, P= .34). Of the 1418 participants analysed for this study, 863 (60.9%) were female. The reported mean age was 18.6 (SD = 3.1). More than half (n= 740, 52.2%) reported either a one-sided or two-sided immigrant background, and almost all (n= 1180, 83.2%) had reached at least the lowest

educational degree (i.e., secondary school) (Tab. 11). Two-thirds of the sample (1083/1418, 76.4%) took part on the follow-up assessment; 538 of the 712 (75.6%) participants assigned to the MCT, and 545 of the 706 (77.2%) assigned to the MCT+.

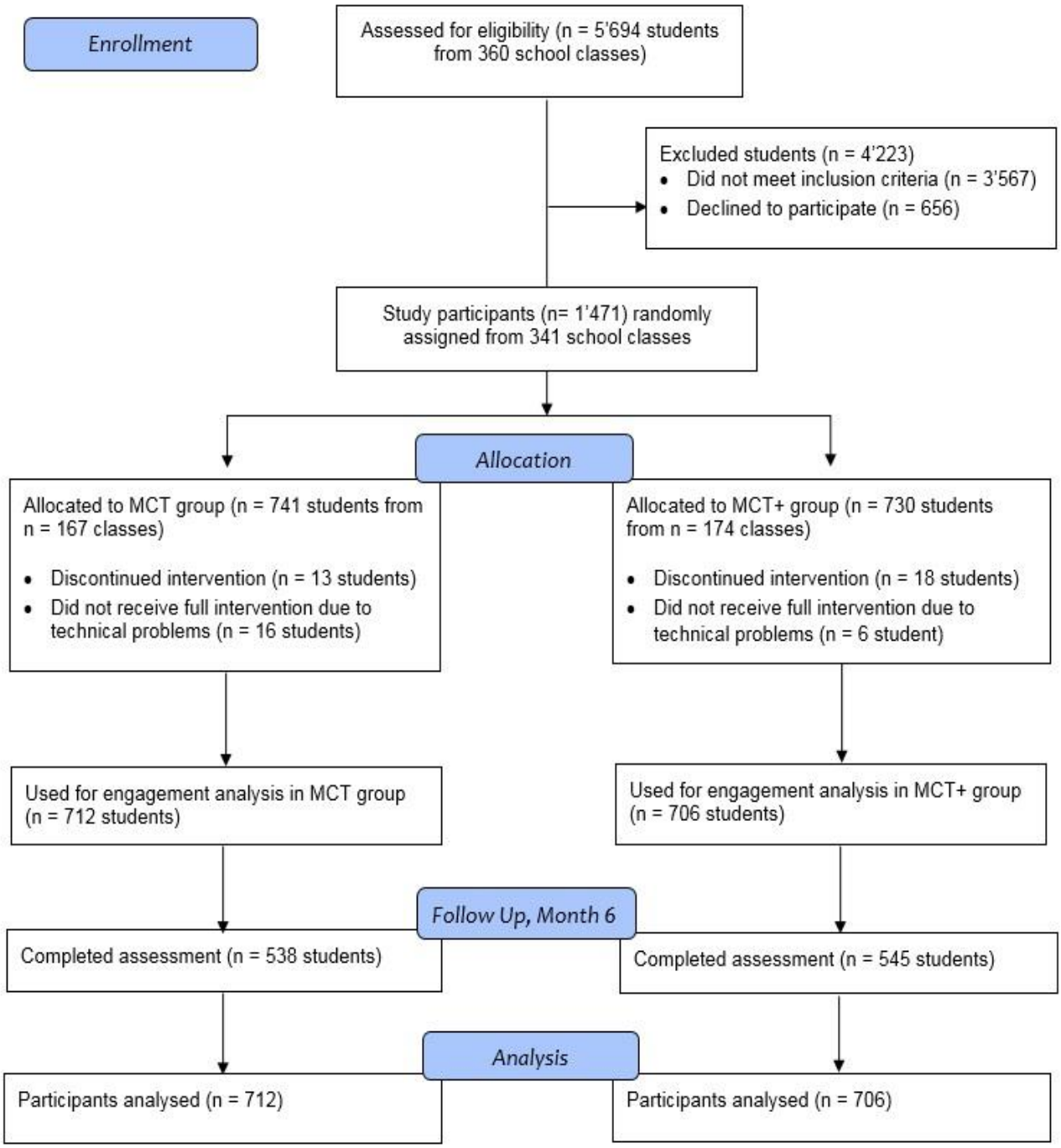

Figure 9. Participants' progress through the trial in Study 3

Use of different program features

Table 10 summarizes different program use characteristics across the total sample and by intervention group. Participants answered a mean of 6.6 (SD = 3.5) out of 11 text message prompts. Each participant received between three and five text messages containing media objects (videos, pictures) which had to be downloaded. On average, participants downloaded 20.5% (SD = 31.5) of the received media content. Participants in the MCT+ downloaded media content significantly more often than their MCT counterparts (23.6% vs. 17.9%, P < .001). Roughly half of the subjects answered all or almost all of their text message prompts. The fewest answers were recorded for the contest prompt at week 8 (24.9%) and for the HAPA stage query at week 10 (42.9%).

Table 10. Use of program components by the overall study sample and by study group. Values represent n (%) unless stated otherwise.

	All (N= 1418)	MCT (n= 712)	MCT+ (n= 706)	*P* value
Questions answered, *M (SD)* [ab]	6.6 (3.5)	6.5 (3.6)	6.8 (3.5)	.22
Percent media objects viewed / of media objects sent, *M (SD)* [ab]	20.8% (31.5)	17.9% (32.6)	23.6% (30.0)	<.001
Answer to Quizzes [cd]				
Quiz Costs (week 1)	975 (68.8%)	481 (67.6%)	494 (70.0%)	.33
Quiz Health (week 5)	898 (63.3%)	438 (61.5%)	460 (65.2%)	.16
Quiz Norms (week 9)	863 (60.9%)	429 (60.3%)	434 (61.5%)	.64
Answer to HAPA stage of change [cd]				
Stage 1 (week 2)	1206 (85.0%)	598 (83.9%)	608 (86.1%)	.26
Stage 2 (week 6)	975 (68.8%)	485 (68.7%)	490 (68.8%)	.96
Stage 3 (week 10)	609 (42.9%)	295 (41.4%)	314 (44.5%)	.25

Answer to smoking-related questions (%) [cd]				
CPD/CPW or Coping strategy (week 3)	992 (70.0%)	490 (68.8%)	502 (71.1%)	.35
CPD/CPW or CS (week 7)	876 (61.8%)	444 (62.4%)	432 (61.2%)	.65
CPD/CPW or CS (week 11)	749 (52.8%)	361 (50.7%)	388 (55.0%)	.11
Answer to Contest (%) [cd]				
Motivational or Quit Contest (week 4)	626 (44.1%)	303 (42.6%)	323 (45.8%)	.23
Motivational or Quit Contest (week 8)	353 (24.9%)	175 (24.6%)	178 (25.2%)	.78
Setting of a quit-date (%) [cd]	156/ 475 (32.8%)	79/239 (33.1%)	77/236 (32.6%)	.92

[a] *t* test,[b] (df=1416), [c] χ^2 test, [d] (*df*= 1). CPD/CPW= cigarettes smoked per day/ cigarettes smoked per week

Engagement analysis

Our inspection of answer behaviour over the three-month intervention revealed different types of engagement trajectory. Some participants exhibited a stable answer pattern (either usually answered or almost never answered text messages). Other participants displayed irregular trajectories. The highest relative loss of inertia measure suggested a three-cluster solution: cluster 1 = stable engagement (SE), cluster 2 = decreasing engagement (DE), and cluster 3 = stable non-engagement (SNE). Based on the average silhouette width (ASW), the quality of the three clusters ranged from poor (cluster 2 = -0.02) to good (cluster 1 = 0.55) and excellent (cluster 3 = 0.70). The low ASW for cluster 2 was because the engagement trajectories included within the cluster differed to a great extent. Some subjects answered text messages only in the beginning, while others answered depending on the topic. There were also some participants who only started to answer text messages at the end of the program (Fig. 10). Since the common element within all these trajectories included in cluster 2 is their instability, the three-cluster solution was considered adequate for the purposes of this study.

Figures 10 and 11 describe the three clusters in different ways. The first figure displays the response or non-response of individuals to each of the eleven prompts within the different clusters. Figure 2 highlights the prototype engagement trajectory within each of the three clusters. The typical participant within cluster 1 (SE) answered to almost all text messages, except for the second request to send their own message to motivate other participants to quit smoking or remain cigarette free. The typical participant within cluster 3 (SNE) did not respond to any of the prompts. Meanwhile, the typical participant within cluster 2 (DE) did not reply to the two message contests, and exhibited a steadily-decreasing response rate. This last pattern is associated with the repetition of questions, like queries relating to the person's HAPA stage of change and cigarettes per day/per week (CPD/CPW).

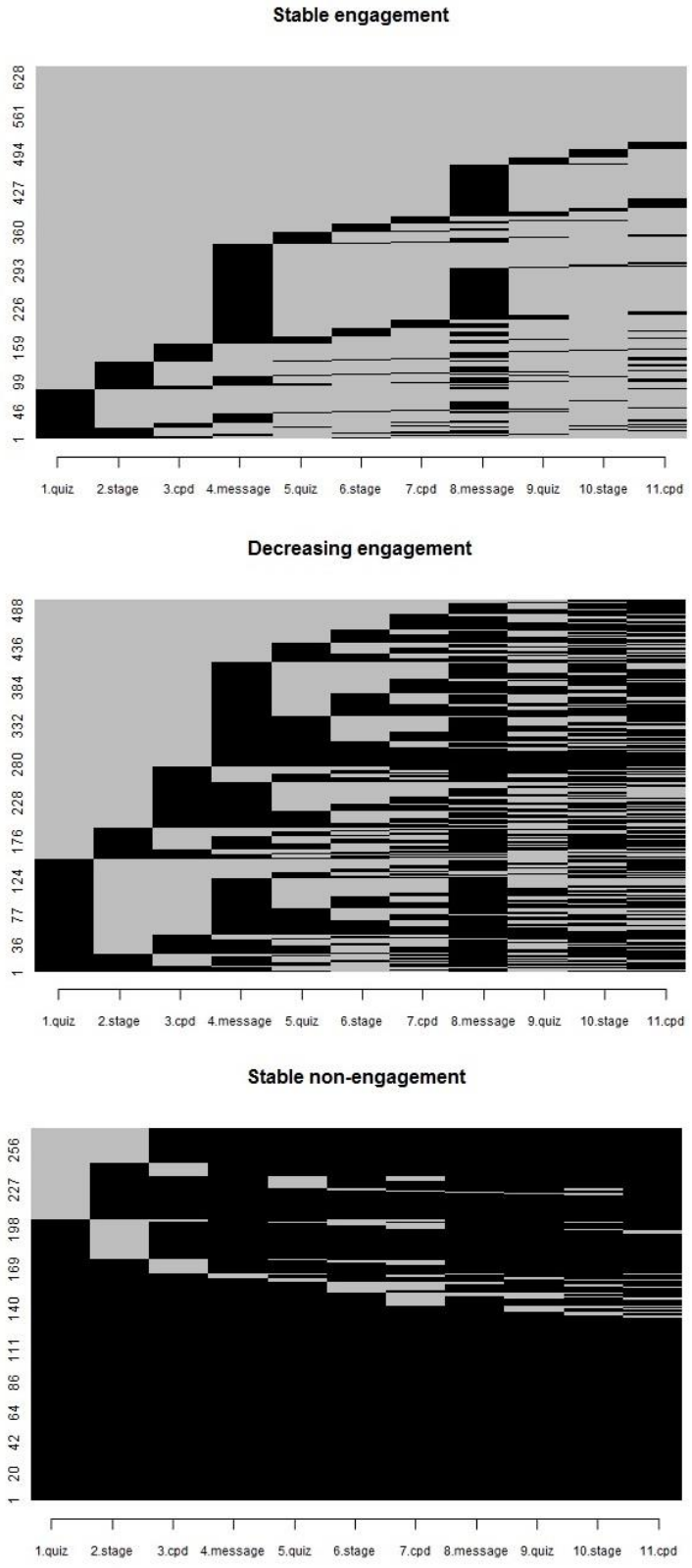

Figure 10. Individual engagement trajectories within each of the three clusters. Rows represent participants, columns represent the 11 prompts which could be answered by the participants. Black boxes represent non-replies, grey boxes replies.

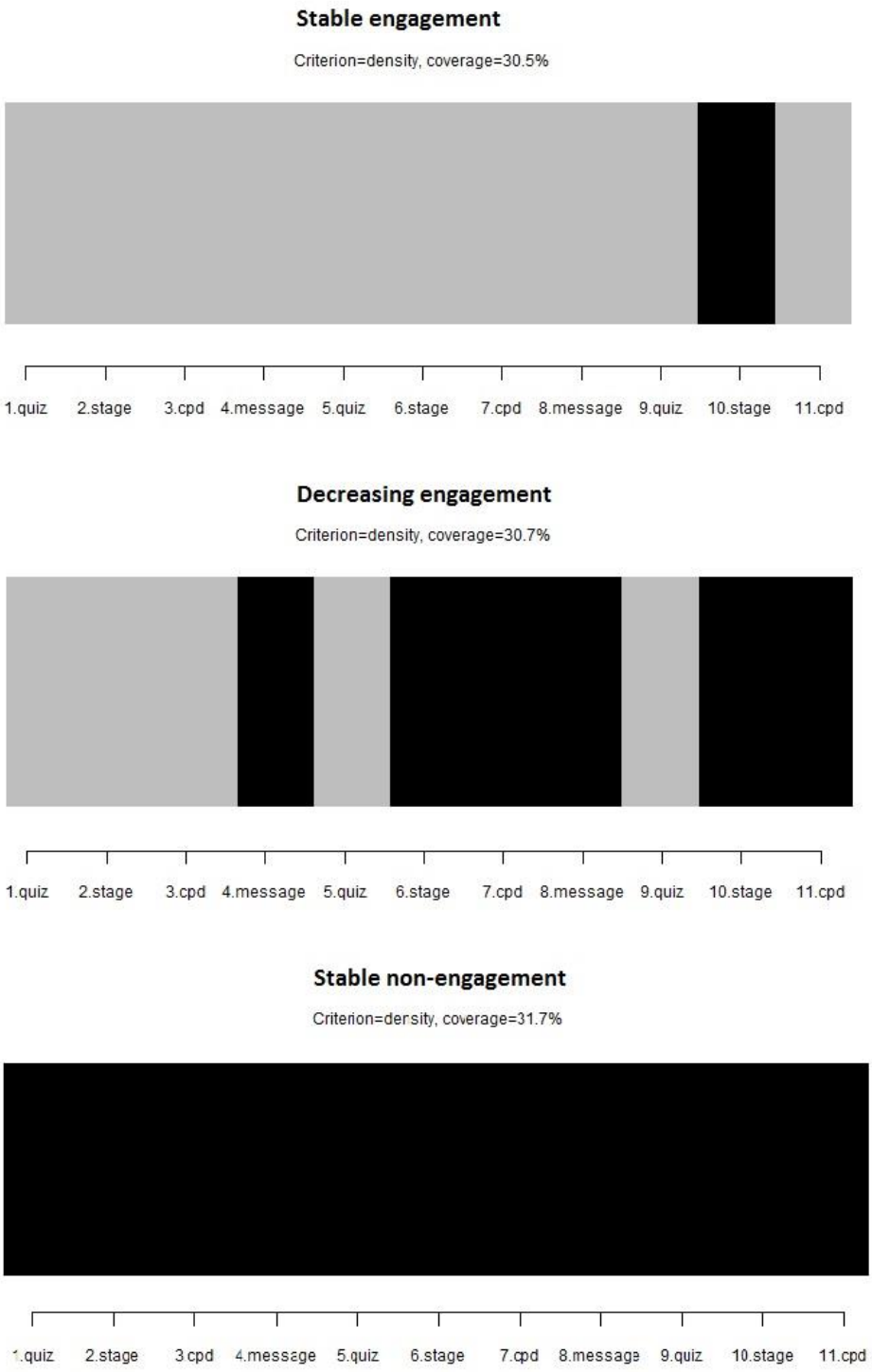

Figure 11. The prototype engagement trajectory within each cluster. Columns represent the 11 prompts which could be answered by the participants. Black boxes represent non-replies, grey boxes replies.

Predictors of engagement trajectory

Table 11 summarizes the baseline characteristics of participants by engagement trajectory. There were significant differences between the three clusters with regard to age (P = .006), immigrant background (P <.001), educational attainment (P = .04), binge drinking (P <.001), HAPA stage of change (P <.05), and self-perceived benefits of quitting (P<.001).

Table 11. Demographic and health behaviour characteristics of the study 3 sample by engagement trajectory. Values represent n (%) unless stated otherwise.

	All (N= 1418)	Stable engagement (n= 646)	Decreasing engagement (n= 501)	Stable non-engagement (n= 271)	*P* value
Intervention group [ac]					
MCT	712 (50.2%)	319 (49.4%)	248 (49.5%)	145 (53.5%)	.48
MCT+	706 (49.8%)	327 (50.6%)	253 (50.5%)	126 (46.5%)	
Female sex [ac]	863 (60.9%)	398 (61.6%)	293 (58.5%)	172 (63.5%)	.35
Immigrant background [ac]	740 (52.2%)	293 (45.4%)	268 (53.5%)	179 (66.1%)	<.001
Age in years, *M (SD)* [bc]	18.6 (3.1)	18.4 (2.8)	18.8 (3.4)	18.9 (2.9)	.006
Educational level [ae]					
Secondary school	1180 (83.2%)	555 (85.9%)	401 (80.0%)	224 (82.7%)	.04
Vocational school	189 (13.3%)	67 (10.4%)	86 (17.2%)	36 (13.3%)	
Technical/ high school or University	30 (2.1%)	13 (2.0%)	10 (2.0%)	7 (2.6%)	
Unknown	19 (1.3%)	11 (1.7%)	4 (0.8%)	4 (1.5%)	

Hours of moderate to vigorous extracurricular physical activity per week, *M (SD)* [bc]	3.5 (3.6)	3.4 (3.4)	3.7 (3.8)	3.2 (3.6)	.08
Number of alcoholic drinks consumed per week, *M (SD)* [bc]	9.9 (12.1)	10.2 (12.1)	10.3 (11.8)	8.4 (12.5)	.09
Binge drinking (%) [ac]					
No	465 (32.8%)	191 (29.6%)	158 (31.6%)	116 (42.8%)	<.001
Yes	952 (67.2%)	455 (70.4%)	342 (68.4%)	155 (57.2%)	
Tabacco smoking status (%) [b]					
Daily smoker	1075 (75.8%)	476 (73.7%)	390 (77.8%)	209 (77.1%)	.22
Occasional smoker	343 (24.2%)	170 (26.3%)	111 (22.2%)	62 (22.9%)	
Number of cigarettes smoked per day (CPD), *M (SD)* [bc]	10.1 (7.3)	9.9 (7.3)	10.5 (7.4)	10.0 (7.1)	.32
Stage of change (%) [ad]					
No intention to quit	396 (28.0%)	200 (31.0%)	124 (24.8%)	72 (26.8%)	.03
Considering quitting	825 (58.3%)	372 (57.6%)	291 (58.2%)	162 (60.2%)	
Serious intention to quit	194 (13.7%)	74 (11.5%)	85 (17.0%)	35 (13.0%)	
Benefits of quitting smoking, *M (SD)* [bc]	1.38 (0.3)	1.41 (0.3)	1.36 (0.3)	1.37 (0.3)	<.001
Previous quit attempts (%) [ad]					
None	507 (35.9%)	247 (38.2%)	173 (34.6%)	87 (32.5%)	.10
One	608 (43.0%)	276 (42.7%)	205 (41.0%)	127 (47.4%)	
Two or more	299 (21.1%)	123 (19.0%)	122 (24.4%)	54 (20.1%)	

Table 12 shows which of the afore-mentioned variables were predictive of engagement trajectory within the multivariate model. Being older (OR= 1.05, P = .04) and having an

immigrant background (OR= 0.76, P = .02) predicted a decreasing engagement with the program compared to a stable engagement. Furthermore, participants who perceived more benefits of quitting were more likely to display stable than decreasing engagement with the program (OR= 0.52 P = .007). Compared to stable engagement, non-engagement was predicted by immigrant background (OR= 0.47, P <.001) and binge-drinking behaviour (OR= 1.54, P = .005). Being a stable non-engager was more likely than being a stable engager, when participants reported an immigrant background and no binge drinking within the month previous to baseline.

Table 12. Predictors of engagement trajectory

	β (SE)	*P* value	OR	CI [95%]
Stable engagement (*ref.*) vs. Decreasing engagement				
Intercept	-0.05 (0.57)	.93		
age	0.05 (0.02)	.04	1.05	[1.003;1.09]
immigration background (*ref.* yes)	-0.28 (0.12)	.02	0.76	[0.59;0.96]
binge drinking (*ref.* yes)	0.01 (0.13)	.98	1.00	[0.78;1.30]
benefits of quitting smoking	-0.66 (0.24)	.007	0.52	[0.32;0.84]
Stable engagement (*ref.*) vs. Stable non-engagement				
Intercept	-1.07 (0.68)	.12		
age	0.05 (0.03)	0.05	1.05	[0.99;1.10]
immigration background (*ref.* yes)	-0.76 (0.15)	<.001	0.47	[0.35;0.63]
binge drinking (*ref.* yes)	0.43 (0.15)	.005	1.54	[1.14;2.08]
benefits of quitting smoking	-0.37 (0.29)	.21	0.70	[0.39;1.24]

Note: R^2 = .04 (Cox & Snell), .05 (Nagelkerke). Model χ^2 (8) = 59.84, p < .001. SE = Standard error, OR = Odds Ratio, CI = Confidence interval.

Engagement trajectories and smoking behaviour

Treatment outcome by type of engagement trajectory and comparisons of outcomes between engagement trajectories are summarized in Table 13. Reach at follow-up differed importantly between stable engagers (84.3%, 545/646), decreasing engagers (74.5%, 373/501), and non-engagers (59.0%, 160/271). Due to this, three statistical models were tested. Only the reduction in cigarettes per day among decreasing engagers differed significantly from stable non-engagers under the CCA, LOCF and ITT assumptions (CCA: β= 0.65, P= 0.02; LOCF: β= 0.43, P= 0.01; ITT: β= 0.54, P= .03). Decreasing engagers smoked significantly fewer cigarettes per day at the end of the intervention than non-engagers.

With respect to the seven-day point prevalence of abstinence at six-month follow-up, no comparison revealed a significant difference under all three assumptions. On ITT analysis, the odds of being abstinent at follow-up was higher among non-engagers than engagers (OR = 1.32, P=.02). But this finding must be interpreted with caution, since bias in the multiple imputation of missing data seems probable due to the different amount of available information at follow-up. Caution is also warranted, as under the missing-as-smoker assumption, the odds for being abstinent turn in the opposite direction.

Table 13. Comparison of treatment outcomes between different engagement trajectories. Descriptive data are based on complete cases.

	Difference in cigarettes per day				7-day point prevalence of smoking abstinence			
		CCA	LOCF	ITT		CCA	MAS	ITT
Engagement trajectory	*M (SD)*	*β (P* value)	*β (P* value)	*β (P* value)	% (n)	OR *(P* value)	OR *(P* value)	OR *(P* value)
SE (Ref.)	2.36 (5.5)	0.25 (.34)	-0.19 (.24)	0.07 (.77)	13.4% (73/545)	1.18 (.16)	0.96 (.76)	1.32 (.02)
SNE	2.43 (5.6)				18.1% (29/160)			
SE (Ref.)	2.36 (5.5)	0.52 (.01)	0.14 (0.32)	0.40 (.04)	13.4% (73/545)	1.05 (.58)	0.97 (.77)	1.11 (.21)
DE	3.44 (7.1)				14.5% (54/373)			
SNE (Ref.)	2.43 (5.6)	0.65 (.02)	0.43 (0.01)	0.54 (.03)	18.1% (29/160)	0.91 (.46)	0.99 (.97)	0.87 (.25)
DE	3.44 (7.1)				14.5% (54/373)			
SE (Ref.)	2.36 (5.5)	0.25 (.046)	0.00 (0.99)	0.17 (.18)	13.4% (73/545)	1.06 (.31)	0.98 (.74)	1.09 (.08)
SNE & DE	2.94 (6.4)				15.6% (83/533)			

Notes: SE=Stable engagement, SNE=Stable non-engagement, DE=Decreasing engagement, CCA=Complete-case dataset, LOCF=Last-information-carried-forward, MAS=Missing-as-smoker, ITT= intention-to-treat dataset, Ref. = reference category. Test value for continuous outcome= t-value; for dichotomous outcome= z value.

4.3.3 Discussion

Using a proactively-recruited sample of smoking adolescents with mixed intentions to quit smoking, the present study examined (1) the use of different components of a mobile phone-based smoking-cessation program; (2) different prototypes of engagement trajectory; (3) the association between engagement trajectories and adolescent characteristics; and (4) the association between engagement trajectories and treatment outcomes.

The main findings are: (1) The components of the mobile phone-based smoking-cessation program were used over the three-month intervention in a regular way, with quizzes being the component with the highest participation rate and repeated smoking-related assessments the least-used component. (2) Three distinct engagement trajectories emerged: two characterized by higher levels of engagement, stable and decreasing engagement, and one by a lower level of engagement: stable non-engagement. (3) Adolescents who were younger, had no immigrant background, perceived more benefits of quitting smoking, and reported binge drinking preceding their baseline assessment were more likely to exhibit a stable engagement trajectory throughout the intervention. (4) Subjects who displayed a decreasing engagement pattern generally reduced their daily tobacco use more than subjects whose level of engagement was low.

This is the first study to examine engagement with a mobile phone-based smoking cessation intervention among adolescents. As expected, trajectories of higher and lower engagement were identified. We found similar results among adolescents as for adults (Schwarzer & Satow, 2012; Balmford & Borland, 2014; Christofferson et al., 2016). We also identified a cluster of people who fully committed to the program, as in the study by Balmford et al. (2014). Similarly, the current study replicates three of the five engagement clusters detected by Christofferson et al. (2016). While our cluster-solution was less fine-grained, the clusters were significantly different with respect to baseline characteristics, contrary to those reported

by Christoffersons et al (2016). Distinct groups are essential if interventions have to be adapted to different types of engager.

Furthermore, this study was the first to examine factors that predict stable engagement with a mobile phone-based smoking cessation program among adolescents. Other than expected from previous studies on mobile phone-based programs for adult smokers (Christofferson et al., 2016; Heminger et al., 2016), engagement was not related to gender. This could be explained by the gender-specific tailoring which was undertaken for *MobileCoach Tobacco* (e.g., the feedback on gender-specific drinking norms). Interestingly, in adolescents, being younger was associated with higher levels of engagement, versus being older among adults (Christofferson et al., 2016). This result suggests a quadratic relationship between age and engagement. Younger and older people might become more engaged for a variety of reasons that include the program being more novel to them, having more free time, or being more likely to commit to tasks in general. Contrary to our assumptions based on studies in adults, lower rates of daily cigarette consumption was not associated with higher engagement.

The current study revealed three further factors, besides age, to be predictive of engagement among adolescents: the individual's immigrant background; their personal outcome expectancies with respect to quitting smoking (i.e., the benefits of quitting); and whether or not they previously engaged in binge drinking. An association between immigrant background and use of the program also was identified in a study by Businelle et al. (2016) which investigated the feasibility and effectiveness of an app-based smoking-cessation intervention among socioeconomically-disadvantaged adults. Especially non-white participants used the two information-delivering features of the app, which were tips and information about medication for quitting. Future studies should investigate whether tailoring mobile phone-based interventions to a person's immigrant background impacts the intervention's effectiveness. In particular, it has to be examined if immigrants show less engagement with mobile phone-based programs due to poorer lexical-grammatical skills

(Melzer, Rissling, & Petermann, 2015) or due to different interests and socialization than non-immigrants.

Compared to previous research, the current findings underline the relevance of hazardous alcohol use in predicting engagement with a smoking cessation program. Recent studies on tobacco interventions (Ames et al., 2010; Ames, Pokorny, Schroeder, Tan, & Werch, 2014b; Paz Castro, Haug, Kowatsch, Filler, & Schaub, 2017) have already highlighted the underestimated role of combined alcohol and tobacco use among adolescents and its association with intervention effectiveness. Not only might mobile phone-based smoking cessation programs be more effective in adolescents who smoke and binge drink (Ames et al., 2010, 2014b; Haug et al., under review; Paz Castro et al., 2017), they also could be more attractive to those adolescents. As such, measures are needed to make smoking cessation programs more attractive for adolescents who smoke but do not drink excessively.

Contrary to previous work on adult smokers (Schwarzer & Satow, 2012; Christofferson et al., 2016; Heminger et al., 2016), we were not able to certainly discern if more engaged subjects were more likely to be cigarette abstinent after the intervention. This was due to the different reach at follow-up of more engaged compared to less engaged participants. The only stable finding over all statistical assumptions was that a decreasing engagement trajectory was associated with a greater reduction in daily tobacco use than a non-stable engagement trajectory. This result suggests that not only stable engagement, but also decreasing engagement might be an indicator of behaviour change. As illustrated by other studies (Balmford & Borland, 2014; Heminger et al., 2016), disengaging from an intervention might not necessarily mean disengaging from behavioural change. Instead, it could indicate a shift from extrinsic to intrinsic motivation (Ryan & Deci, 2000). These results support the claim by Yardley et al. (Yardley et al., 2016) to examine ways of improving "effective engagement" in subjects rather than simply more engagement, with "effective engagement" defined as sufficient engagement with the treatment to achieve intended outcomes.

One major challenge of future research, however, will be to sort out which kind of intervention is apt for non-engagers. One starting point will be to adapt smoking cessation programs for adolescents to address immigrant backgrounds and drinking behaviours to prevent stable non-engagement and, thereby, potentially enhance treatment effectiveness. Considering that most stable non-engagers were more highly motivated to quit smoking at baseline than most stable engagers, one question to answer will be if actions must be undertaken to increase active participation or not.

The findings of this study must be interpreted in view of its limitations. First, only answers to weekly prompts were included for engagement analysis. Other components of the program — such as downloading media content, setting a quit date, and extra-curricular texting behaviours — were not included in our analyses; and these components could all be analysed to determine their own predictive values (cf. Heminger et al., 2016; Whitton et al., 2015). However, our rationale for selecting answers to prompts that were identical for all participants was to render our inter-group comparisons more interpretable. Second, that answers to weekly prompts were rewarded with 0.50 Swiss francs to cover the expenses of the adolescents might have influenced the adolescents' likelihood of responding. Third, as already emphasized by Heminger et al. (2016), quantity and quality of answers to prompts could qualitatively differ (e.g., a smoker who replies to all smoking-related prompts and indicates greater daily use of cigarettes). Rather than just analysing registered events, future qualitative work should investigate whether the content of answers is associated with treatment outcomes. In addition, qualitative research should further investigate the different forms of motivation underlying engagement trajectories among smokers. As stated elsewhere (Businelle et al., 2016), some highly-engaged participants might have seen the program as integral to maintaining abstinence, while other non-abstinent smokers may have remained highly engaged to prepare for future smoking cessation attempts or merely to receive the offered remuneration. Finally,

the current study relied on self-report data of smoking behaviour, which bears the risk that the results may have been influenced by social desirability.

In summary, in our study, adolescents who smoked engaged to a large extent with a mobile phone-based smoking cessation program, irrespectively of their initial intention to quit smoking. Decreasing engagement was in turn clearly associated with better long-term treatment outcomes. Further efforts should be undertaken to increase program engagement among older smokers with an immigrant background who do not drink excessively. In addition, future studies should not only examine the use of specific program components, but also users' engagement trajectories to better understand the mechanisms behind behavioural change.

5. General Discussion

The primary aim of the present thesis was to examine how cigarette smoking and problematic alcohol use can be best addressed via mobile phone-based early intervention programmes in adolescents. As this is still an emerging and rapidly-changing field of research, factors which might influence the effectiveness of mobile phone-delivered interventions remain unknown. Following recommendations of recent meta-analyses on this topic, this thesis not only examined the effectiveness of a mobile phone-based intervention on alcohol use in adolescents within an adequately-powered study (Study 1), it also evaluated socio-demographic, health-related, and socio-cognitive moderators of the effectiveness of this particular intervention (Study 2). One last influencing factor that was analysed within this thesis was adolescents' levels and patterns of engagement with the mobile phone-based intervention (Study 3). By focusing particularly on trajectories of engagement, this thesis attempts to provide insights into the behavioural processes which adolescents undergo when using a mobile phone-based intervention.

The next section of this chapter will summarize and discuss the results of the studies individually. The last three sections, respectively, discuss the methodological limitations of the currently presented research; implications of the findings and their meaning with respect to potential directions for future research; and how the findings gleaned here might impact future tobacco and alcohol use prevention and reduction.

5.1 Summary and discussion of study results

The first research question of this thesis can be answered by stating that a primarily mobile phone-based intervention — grounded in the social norms approach (Perkins, 2003), but also incorporating elements from social cognitive theory (McAlister et al., 2008) and the health

action process approach (HAPA, Schwarzer, 2008) — appeared to be effective at reducing the prevalence of problematic alcohol use in adolescents. The findings of the adequately-powered first study replicate those of previous feasibility studies (Haug, Schaub, Venzin, Meyer, John, et al., 2013; Mason et al., 2014; Moore et al., 2013; Suffoletto et al., 2012). Especially noteworthy is that, in this study, the effectiveness of this early intervention was replicated in a diverse population of adolescents recruited from vocational schools, which was a major concern of previous studies including primarily college samples (Danielsson et al., 2014; Donoghue et al., 2014; White et al., 2010).

The second research question addressed by this thesis can be answered by stating that smokers and higher-educated adolescents appeared to be the ones who benefitted most from an early intervention targeting alcohol use. The results of subgroup analyses within Study 1 suggest that adolescents characterized as high-risk alcohol users (at least two episodes of RSOD within the preceding month) benefited most from the intervention. The more pronounced intervention effect we observed in heavy drinkers is consistent with the results of previous research (Bertholet et al., 2015b; Walters & Neighbors, 2005). However, this moderating effect of severity of alcohol use was put into another perspective in Study 2, in which different moderators of intervention effectiveness were tested concurrently to sort out which ones were the most relevant. In our second study — more than any other socio-demographic, health-related or socio-cognitive characteristics — smoking status and educational attainment most significantly influenced the effect of the early alcohol intervention that was administered. The mobile phone-based alcohol intervention was most beneficial among smokers. This is of interest, because prior studies have universally failed to evaluate smoking as a moderator of response to early alcohol interventions, even among studies that examined multiple moderators of outcome (Carey et al., 2007; Elliott et al., 2008; Henson et al., 2015). Aware of the high rate of co-occurrence of tobacco and problematic

alcohol use in adolescents (Haug, Schaub, Gross, John, & Meyer, 2013; McKee & Weinberger, 2013), two prior pilot studies (Ames et al., 2010, 2014b) and one larger-scale study (Haug et al., under review; Haug et al., 2012) have investigated the effectiveness of an integrated intervention that targeted both smoking cessation and problematic alcohol use reduction; this time smoking cessation was the primary outcome of interest in all three studies. In the two pilot studies, there was a trend of tobacco abstinence rates being higher among adolescents who were allocated to an integrated intervention than in those who only received standard treatment for smoking cessation (Ames et al., 2010, 2014b). However, the larger-scale study failed to identify an overall significant difference between an integrated programme and a smoking cessation only programme, either in terms of reducing the number of cigarettes smoked per day or increasing the rate of smoking abstinence (Haug et al., under review; Haug et al., 2012). Yet, the integrated programme appeared to be more effective in smokers with higher-risk drinking patterns than the smoking cessation only programme. These conflicting results indicate the need for further research to decide if and how mobile phone-based early interventions can best address concomitant tobacco use and problematic alcohol use.

In addition to the impact of smoking status, the intervention we examined was also more effective in more highly- versus less-educated subjects. To our knowledge, ours is the first study to document any moderating effect of educational level on the effectiveness of a mobile phone-based intervention. The failure of previously-published studies to do so could be because most of these previous studies were conducted on college students only (Carey et al., 2007; Elliott et al., 2008; Henson et al., 2015), whereas we studied students in vocational schools. This discrepancy in findings illustrates how crucial it is to test early interventions targeting adolescents in more diverse populations, something that only a few studies have done to date (Bock et al., 2016; Haug, Schaub, Venzin, Meyer, & John, 2013b; Suffoletto et

al., 2012). This moderating effect of educational attainment comes somewhat as a surprise, considering the essential nature of most mobile phone-based interventions. Typically, these interventions contain short, simple messages and simple graphical representations, which is why they would appear promising as a template for use to overcome socio-educational disparities between adolescents (Inchley et al., 2016). However, it remains an open research question as to whether an intervention's effectiveness might be improved in less-educated adolescents by simplifying the intervention even more (Melzer et al., 2015), or by otherwise altering the content (Bock et al., 2015, 2016). It is possible that other factors, like need for cognition (Haug et al., 2010), is responsible for the reduced effectiveness of mobile phone-based early interventions in less-educated adolescents; with need for cognition referring to an individual's engagement in effortful cognitive activities (Cacioppo & Petty, 1982).

A further conclusion from Studies 1 and 2 is that mobile phone-based alcohol interventions might be indicated for some adolescents drinking within low-risk limits, to prevent later problematic alcohol use. Study 1 identified no negative intervention effects on adolescents drinking within low-risk limits. This result agrees with the results of previous research on normative feedback (Bertholet et al., 2015b; Prince et al., 2014), in which non-problem drinkers did not increase their drinking after receiving the intervention. Rather, a tendency towards a protective effect of the intervention was observed among non-problem drinkers (at follow-up, 21.2% of the initially low-risk control group subjects reported RSOD versus only 16.8% of the initially low-risk intervention group subjects). The results of our second study, however, suggest that this protective effect might only exist for non-problem drinkers who smoke and are higher-educated. Non-smokers who reported lower-risk alcohol use did not appear to benefit from the mobile phone-alcohol intervention. Previous research on universal prevention strategies (Spoth et al., 2008; Stockings et al., 2016), which typically address adolescents before reporting substance use, has shown that more general skill-based

interventions that include components on social competence and social influences are promising, in terms of reducing future problematic alcohol use. In a recent pre-post feasibility study, a more general, life skill-based programme delivered via mobile phone increased life skills in adolescents (Haug et al., 2017). However, the programme's preventive effect on substance use remains to be evaluated within the context of a randomized controlled trial. Future studies need to compare a substance-specific alcohol intervention against a life skills-based intervention, in terms of preventing problematic alcohol use in smokers who drink within low-risk limits.

The third research question this thesis addressed can be answered in two parts, as follows. First, adolescents in our sample tended to engage, to a large extent, with the mobile phone-based tobacco intervention that was offered them, especially if they were younger, non-immigrants, risky drinkers, and perceived more benefits to, than disadvantages of quitting. Second, both higher and lower engagement trajectories were observed, and the association between level of engagement and outcomes appeared to be more complex than that postulated by Perski et al. (2017).

With regard to the first conclusion, some of the predictors discussed in previous studies on engagement (Perski et al., 2017) were also confirmed for their influence on engagement trajectories; though these associations were not always in the expected direction. Immigrant background was revealed to be inversely associated with a higher engagement trajectory, which is consistent with findings summarized in a recent review on engagement with technology-based health change interventions (Perski et al., 2017). Beliefs, which in this study were measured at baseline as benefits of quitting smoking, were also found to predict engagement trajectories (Perski et al., 2017). Age was also confirmed as an influential factor; however, among adolescents, younger age predicted higher levels of engagement, contrary to older age, as previously documented in adults (Perski et al., 2017). Other characteristics that

have been discussed in current literature (Perski et al., 2017) — like gender and motivation to change — were not associated with any particular engagement trajectory in our study. Based upon correlational observations, a U-shaped relationship between motivation and engagement is assumed (Perski et al., 2017). This means that those who are least and most motivated to change their behaviour would be hypothesised to disengage quickly from an intervention, since they rapidly either fail or succeed at meeting their initial objective. There are at least two potential reasons why motivation to quit failed to predict outcomes in our sample. First, it is possible that, because motivation to quit was measured only indirectly, by assessing intention to change, we might have failed to observe an association. Second, it also is feasible that the level of motivation that participants reported at baseline did not reflect their level of motivation over the course of the intervention. If the latter of these two potential explanations occurred, it highlights the need to analyse motivation trajectories to better understand engagement trajectories. A potential framework for analysing engagement with an intervention at different motivational stages will be discussed in chapter 5.3. That gender was not found to predict the level of program engagement might be due to efforts that had been put into tailoring the intervention to individuals, efforts that included gender-specific text messages and graphical representations. Beyond all this, the third study in the current dissertation contributed to current knowledge by revealing one specific predictor of higher engagement trajectories within a mobile phone-based smoking-cessation programme: problematic alcohol use reported for the time preceding the intervention. Our second study's results already suggested that adolescents who concurrently smoke and drink above lower-risk limits react differently to early interventions. Our third study's results complement this, by showing that early interventions might be more attractive to such adolescents.

With regard to the second conclusion, what we witnessed in our third study suggests that it matters whether engagement is conceptualised in a more static or dynamic way. For example,

most components of the mobile phone-based smoking-cessation programme were used over the three-month intervention regularly, with quizzes the component with the highest participation rate, and repeat smoking-related assessments the least-used component. Yet, conceptualising engagement in a more dynamic way, three distinct engagement trajectories emerged: two characterized by higher levels of engagement, stable and decreasing engagement, and one by a lower level of engagement: stable non-engagement. These results are similar to previously-reported findings among adults (Christofferson et al., 2016). This being said, adolescents who exhibited the highest engagement trajectory did not benefit most from the intervention, either in terms of reduced cigarette smoking or smoking abstinence, which was contrary to previous findings reported for adult smokers (Schwarzer & Satow, 2012; Christofferson et al., 2016; Heminger et al., 2016). Instead, subjects who displayed a decreasing engagement pattern generally reduced their daily tobacco use more than subjects whose level of engagement always was low. This suggests that not only the highest form of engagement, as suggested by other studies (Balmford & Borland, 2014; Christofferson et al., 2016), but also decreasing engagement might be an indicator of behaviour change. Previous correlational studies on engagement had already questioned whether disengaging from the intervention was equal to disengaging from behavioural change (Balmford & Borland, 2014; Heminger et al., 2016). Using sequence analysis to examine engagement trajectories and their relation to interventions' outcomes, this question can be supported. As such, these findings throw new light onto more static conceptualisations of engagement (Perski et al., 2017), highlighting the importance of thinking about more dynamic ways of conceptualising engagement (Han et al., 2012; O'Brien & Toms, 2008; Yardley et al., 2016). Especially, these results support the claim of the expert group around Yardley (2016) to find ways of measuring and establishing "effective engagement" in interventions rather than just higher engagement.

5.2 Limitations and implications for future research

The findings of this thesis must be interpreted in light of its methodological limitations. First, all three studies relied on self-reported data. Using self-reported data without verifying them objectively increases the risk of bias in multiple domains, including bias caused by social desirability (van de Mortel, 2008). Means that we adopted to minimize the under- and over-reporting of substance use included the assurance of confidentiality. Both in Study 1 and 2, anonymous assessments were conducted via tablet computers, and there was no direct personal contact at either baseline or follow-up, which may have decreased the need for social desirability and thereby increased the accuracy of self-reported data. In the third study, anonymous assessments were conducted only at baseline, with telephone interviews undertaken at follow-up. Objective data are always desirable to validate findings (Dolcini, Adler, Lee, & Bauman, 2003). However, including objective measurements like biochemical verification in early interventions might be impracticable (West, Hajek, Stead, & Stapleton, 2005) or might reduce participation rates, by creating user burden or reactivity (McClure & Gray, 2013). By this, conclusions about an intervention's feasibility could be biased. Other promising objective measurements, like ecological momentary assessments (EMA, Shiffman, Stone, & Hufford, 2008), have been discussed for its potential to reduce recall bias by meanings of repeated sampling of adolescents' behaviour in real time and natural environment (Kuntsche & Labhart, 2012; McClure & Gray, 2013; Thrul, Bühler, & Ferguson, 2014). This assessments have lately been refined through location monitoring or so called *geofencing* (Naughton et al., 2016). However, future research still needs to find the right balance between collection of valid data and intrusiveness.

A second factor that might have biased the studies' outcomes is the rewards that each adolescent earned by participating. For example, in the third study, answers to weekly prompts were rewarded with 0.50 Swiss francs to cover the subjects' expenses. This might

have influenced their likelihood of responding. Without this incentive, the engagement trajectories could have appeared different, and/or more adolescents may have exhibited a lower engagement level. Thus, future research on early interventions must find ways to engage adolescents without influencing the validity of their responses or behaviours. One potential way to do so could be by introducing a contest within the early intervention. A recently-proposed study on the feasibility of a mobile phone-based programme to improve life skills in adolescents has employed this approach (Haug et al., 2017). In this study, up to ten prizes are offered, which can be won at the end of the intervention. The chance to win a prize are higher for adolescents who engage with the intervention in different ways (e.g., by answering text messages, watching videos, sending pictures, or voting for pictures sent by other participants). However, participating in every intervention prompt does not guarantee a win. Replication of engagement trajectories within mostly unrewarded interventions is a next step. The last fact that might have biased the results of our studies is that we used a convenience sample of school classes willing to participate in the studies, which limits the generalizability of the findings. The large samples suggest that any potential bias should be minimal; nevertheless, future research should use more heterogeneous samples that are more representative of adolescents in the general population.

A third methodological issue is that, even if the mobile phone-based intervention was predominant in our three studies, the effects of the interventions could also be attributed to the web-based normative feedback provided right after the baseline screening or their combination. The findings are also all based on a relatively short follow-up period, with only one assessment six-months subsequent to the baseline assessment. Even if this is a relatively short period for establishing the efficacy of a mobile phone-based intervention, it was one of the longest periods examined within engagement analysis. Only another study documented associations of engagement patterns with a six-month outcome (Heminger et al., 2016).

Another limitation of the research presented in this dissertation is that all the results are based on quantitative measures and qualitative changes have not been studied. For example, in Studies 1 and 2, the focus was on decreased frequency or rate of problematic alcohol use, rather than measuring any decrease in harm related to problematic use or increased well-being in subjects. Furthermore, in the third study, the amount of answers to the text messages was analysed longitudinally (quantitative), but the content of the answer was neglected (qualitative) (e.g., an adolescent could reply to all smoking-related prompts, but indicate greater daily use of cigarettes). Future research should investigate if adolescents also report higher quality of life, and if the nature of the answers is as the intervention intended them to be (similar to the study of Irvine et al., 2017).

Also, within the format of brief screening and intervention, only a limited number of factors can be assessed, which is why we may have overlooked potentially-influential moderators in our second study (e.g., the age of alcohol drinking onset, the degree of readiness-to-change). The relatively scarce information available from the adolescents also limited the imputation techniques available for Study 3, for which a sizeable number of non-engagers could not be interviewed at follow-up. While the available information was sufficient to impute missing data in Study 1, Study 3 demonstrated that missing-not-at-random poses a major problem when evaluating behavioural processes. Future studies should be aware of this problem and either a) adopt measures to minimize missing data at follow-up (e.g., by offering greater incentives or conducting follow-up within scheduled class time), b) conduct sensitivity analyses similar to the ones we employed in Study 3, or c) use statistical methods that account for missings-not-at-random in the equations (cf. Joint Models, Scherer, Ben-Zeev, Li, & Kane, 2017).

The last limitation might be that mediating processes were not analysed, contrary to the recommendations of (Mason et al., 2014). In this regard, the only conclusions that can be

drawn from this thesis are that there was no effect of the alcohol intervention on perceived peer drinking (path a in a mediation model (cf. Baron & Kenny, 1986)). The mechanisms of action are, hence, still unreported for mobile phone-based interventions, though there is some research in the more generic field of technology-based interventions (cf. Figure 2, Perski et al., 2017). To identify mechanism of action, however, repeated and detailed assessments of mediating factors are often needed (e.g. Berli et al., 2014; Schwarzer & Luszczynska, 2008), which might on the other hand decrease adolescents' engagement with an intervention. Micro-randomized trials[8] (Klasnja et al., 2015; Nahum-Shani et al., 2016) might be an alternative for examining mediating processes. In such trials, single components of an intervention can be tested for its associations with proximal outcomes. For example, adolescents drinking above low-risk limits can be randomly assigned within an intervention to either receive or not receive a text message addressing peer drinking norms at a specific time point or within a specific context, and ultimately test its effect on their drinking behaviour. In so doing, findings on descriptive norms as a mediator of alcohol interventions could be replicated more rapidly in non-college samples (Reid & Carey, 2015b).

5.3 Strengths and implications for future research

The three studies included in the present thesis were unique in their composition and have several important strengths worth mentioning. First, it can be stated that mobile phone-based interventions appeared effective at reducing problematic alcohol use and, moreover, exhibited no iatrogenic effects (Werch & Owen, 2002). Rather, they demonstrated preventive effects in non-problem drinkers. Screening and delivering brief alcohol interventions to all adolescents has two advantages: 1) implementation of early interventions is more feasible (e.g., school

[8] A similar approach is also known as sequential multiple assignment randomized trial (SMART) (L. M. Collins, Murphy, & Strecher, 2007).

classes can participate in their entirety); and 2) discrimination against certain students can be minimized. However, this potential preventive effect in non-problem drinkers warrants further study, since the subgroup analyses in the first two studies were slightly underpowered. Also, future studies might want to test the effect of alcohol-specific versus life skill-based mobile phone-based interventions at preventing problematic alcohol use in the subgroup of non-problem drinkers.

Second, this thesis underlines the influence of concurrent tobacco and problematic alcohol use on the effectiveness of and engagement with substance-specific early interventions. This being said, further research is needed to understand if and how early interventions can be tailored to this fact. Mobile phone-based interventions seem promising, since text messages with information about the relationship between alcohol and tobacco use could be sent at times when adolescents typically go out to socialize, when the probability for using both substances is highest (Jiang & Ling, 2013). Yet, in a larger-scale study (Haug et al., under review) additional text messages, which were sent at self-indicated typical drinking times and promoted sensible drinking, were not found to increase the effectiveness of a smoking cessation programme in adolescents. In this study, however, only risky drinkers received those text messages, and subjects only were asked about their personal typical drinking times at baseline. Typical drinking times could have changed over the course of the intervention, and the adolescents could have received the text messages at times when the information was irrelevant or late. Future investigators should use micro-randomized trials to optimize interventions and to test the effects of just-in-time delivered text messages (Klasnja et al., 2015; Nahum-Shani et al., 2016). For this, either the state of receptivity can be assessed in adolescents (e.g. ‘are you going out and have a drink this evening?’) or information on location can be retrieved from their mobile phones (e.g. *geofencing* (Naughton et al., 2016)).

Third, this thesis makes evident how important it is to analyse longitudinal versus single engagement data. Conceptualising engagement in a more dynamic way can yield interesting insights into the "black-box" of behavioural change within early interventions. As can be seen from our third study, dis-engagement might be a component of behavioural change and predictive of an intervention's success (Yardley et al., 2016). For future studies, some integration of the conceptual framework for engagement (Perski et al., 2017) and the health action process approach (HAPA, Schwarzer, 2008) might be useful. As such, knowledge about the different stages of change can be used to test hypotheses and predict engagement with mobile phone-based interventions. Figure 3 displays graphically how the conceptual framework of Perski et al. (2017) could possibly be complemented with the assumptions of the health action process approach (HAPA, Schwarzer, 2008), and where the findings of Study 3 could be incorporated.

In the current framework, mechanism of action, like beliefs, motivation, and skills, are supposed to moderate the relationship between a technology-based intervention and the engagement with the intervention (cf. Figure 2, Perski et al., 2017). However, as known from the previous work on HAPA (Lippke, Fleig, Wiedemann, & Schwarzer, 2015; Schwarzer, 2008), it seems probable that some of these are only predictive for engagement at the beginning of the behaviour change process (*motivational phase*) and less so, when the behaviour change process has already started (*volitional phase*). For example, beliefs and attitudes in the engagement framework resemble risk perception and outcome expectancies in the HAPA (Schwarzer, 2008), which are relevant only in the motivational stage. On the other hand, other relevant factors associated with successful behaviour change, like self-efficacy, planning or action control (e.g. Scholz, Schüz, Ziegelmann, Lippke, & Schwarzer, 2008; Sniehotta, Scholz, & Schwarzer, 2005; Wiedemann, Schüz, Sniehotta, Scholz, & Schwarzer, 2009), are not included in the engagement framework within the mechanism of action (cf.

Figure 2). A differentiation into motivational and volitional processes within these mechanism of action is therefore proposed. This differentiation seems further required, since previous research on motivation already documented motivation to be both predictive for engagement and disengagement (Perski et al., 2017, cf. chapter 2.3). Hence, future research could evaluate whether (a) a positive association exists between motivational stage and engagement (green line in Figure 3), and (b) a negative association exists between volitional stage and engagement (red line in Figure 3); and (c) which factors moderate these associations (e.g., outcome expectancies, self-efficacy, implementation intentions). This new approach would be in line with the claim to examine not just engagement, but rather "effective engagement" in technology-based interventions (Yardley et al., 2016). However, qualitative research is also needed to better understand, which elements are most or less engaging and why subjects start to disengage from an intervention (Yardley et al., 2016). New proposed attributes that should be part of the conceptual framework and replicated in futures studies are trajectories for engagement and concurrent substance use patterns for population characteristics (cf. Figure 2).

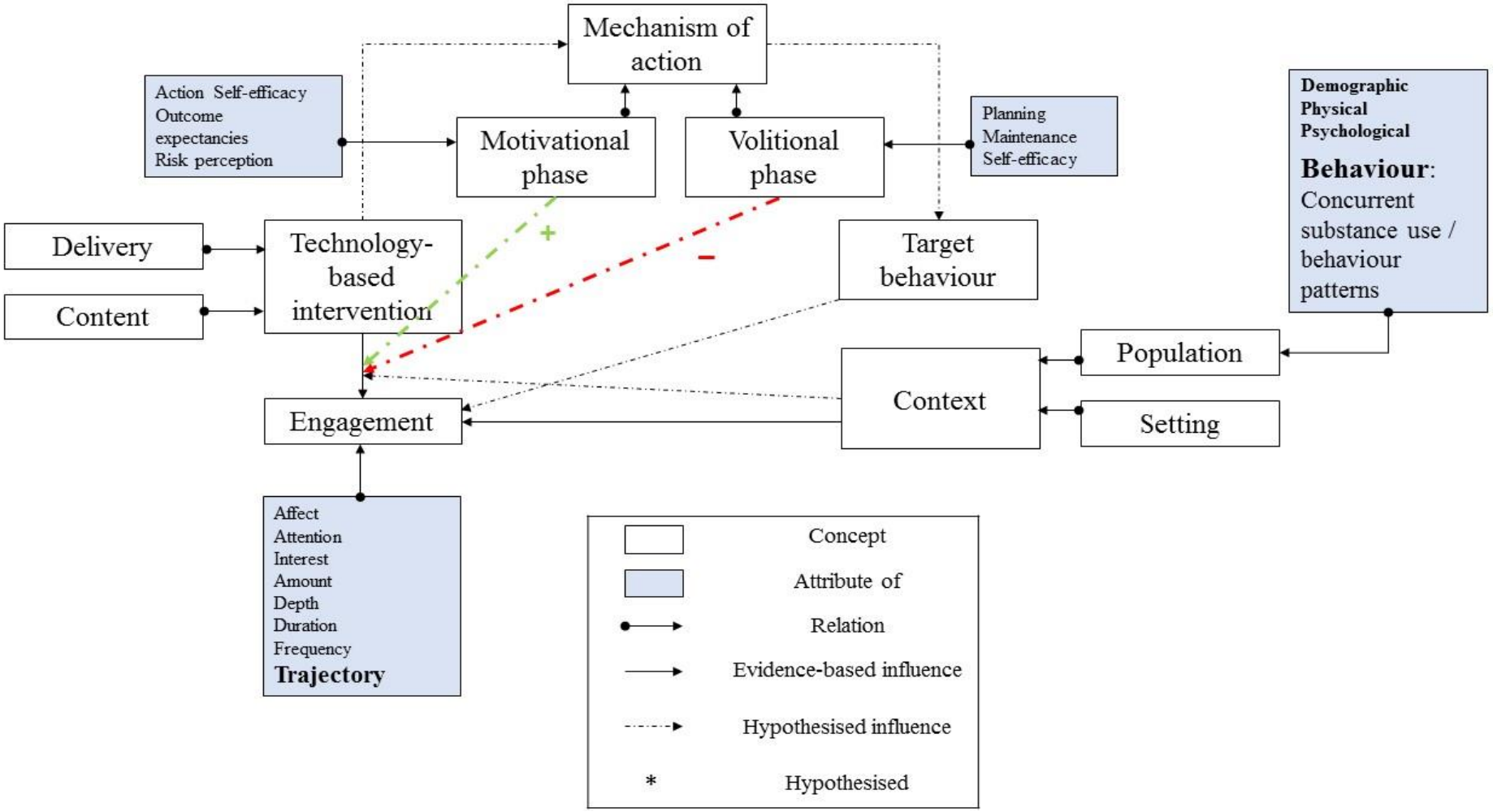

Figure 12. Conceptual framework of direct and indirect influences on engagement with technology-based interventions ((Perski et al., 2017) complemented with the health action process approach model (Schwarzer, 2008)

One major challenge of future research, however, will be to evaluate which kind of intervention is most suited for stable non-engagers, as could be seen from Study 3. As suggested by the findings in Study 3, smoking cessation programs for adolescents should firstly be adapted to address immigrant backgrounds and drinking behaviours to prevent stable non-engagement and, thereby, potentially enhance treatment effectiveness. Considering that in Study 3 most stable non-engagers were more highly motivated to quit smoking at baseline than most stable engagers, one question to answer will be if such adolescents would better benefit from another mode of intervention delivery (face-to-face or a combined intervention).

5.4 Implications for future implementation practices

The findings of this thesis have several implications related to the implementation of early interventions. First, the delivery of screening and brief interventions via mobile phones should be given priority over face-to-face interventions, since they not only seem to be cost-effective (Stockings et al., 2016; Suffoletto, 2016), but engaging for a sizeable majority of adolescents. Second, practitioners should choose a proactive recruitment approach to ensure broad dissemination of early interventions. Across the three studies described in this thesis, three out of four students who were invited to participate in the programme and study agreed to do so. Given the 3-month duration of the respective programmes and the requirement for subjects to provide a mobile phone number, this roughly 75% participation rate was considered very high. A comparable study recruiting young people for a study comparing a web-based alcohol intervention and e-mails achieved a participation rate of just 37% (Bertholet et al., 2015a). In another study (Doumas et al., 2014), in which adolescents also were recruited for a web-based alcohol intervention, but within school classrooms, the participation rate was 52%. This underlines the importance of a proactive approach to recruitment. Third, even if no negative

effects were assessed among adolescents who did not report substance use, practitioners should refrain from providing superfluous information to adolescents who drink within low risk limits and do not smoke, as their substance use pattern can be considered relatively stable (McKee & Weinberger, 2013; Nelson et al., 2015). They could choose to deliver more general life skills-based programmes, if such are available, or instead, defer delivering any substance-specific technology-based intervention until this substance use pattern changes appreciably.

To conclude, mobile phone-based early interventions appear to not only to be feasible, but also suited for preventing tobacco and alcohol use in adolescents. From now on, future research should extend knowledge on the mechanisms of action underlying behaviour change. To this scope, mixed methods and qualitative research should be given priority to obtain a more in-depth understanding of behavioural processes within these interventions. In so doing, effectiveness and dissemination of such interventions might be increased.

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7. Curriculum Vitae

Personal Data

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Education

Since 09.2014	**Doctoral program in Psychology (PhD)** Thesis: **Can text messages make you change? Mobile phone-based interventions for tobacco and alcohol use reduction in adolescents** *University of Zurich, at the Swiss Research Institute for Public Health and Addiction (ISGF)*
09.2010- 09.2013	**Master of Science UZH in Psychology (MSc)** Major Subject: Clinical and Health Psychology Minor Subject: Swiss History *University of Zurich, Zurich*
09.2006 – 09.2010	**Bachelor of Science UZH in Psychology (BSc)** First Minor Subject: Swiss History Second Minor Subject: Science of Education *University of Zurich, Zurich*
08.2002 – 08.2006	**College Kantonsschule Oerlikon (KSOe)** Major Subject: Latin *Kantonsschule Oerlikon, Zurich*

Professional experience and teaching

Since 05.2014	Research Associate and PhD student, *Swiss Research Institute for Public Health and Addiction (ISGF), Zurich*
08.2013-01.2016	Teaching assistant for the courses “Language Psychology” and

	"Emotion & Motivation", *Swiss Distance University, Brig*
08.2013- 01.2015	Lecturer for the course „Introduction to Psychology- Training for medical masseur", *Fachschule Dickerhof AG, Emmenbrücke*
05.2012-05.2014	Research Assistant, *Swiss Research Institute for Public Health and Addiction (ISGF), Zurich*
09.2011 – 06.2012	Teaching assistant for the courses "Psychological Methods- Statistics I & II", "Psychological Methods- Introduction to computer based analysis of data" and "Psychological Methods: Data collection, analysis and presentation", *Institute of Psychology, University of Zurich*
09.2010 – 03.2012	Research Assistant on Dr. W. Möhring's study "Mental object rotation and motor development in 8- and 10-month-old infants", *Institute of Psychology, University of Zurich*

Scientific Work

Selected publications in peer-reviewed journals

Paz Castro, R., Haug, S., Filler, A., Kowatsch, T., Schaub, M. P. (2017). Engagement within a mobile phone-based smoking cessation intervention for adolescents and its association with participant characteristics and outcomes. *Journal of Medical Internet Research, 19*(11). doi: http://dx.doi.org/10.2196/jmir.7928

Paz Castro, R., Haug, S., Kowatsch, T., Filler, A., Schaub, M. P. (2017). Moderators of outcome in a technology-based intervention to prevent and reduce problem drinking among adolescents. *Addictive Behaviors, 72*:64-71.

Haug, S., Paz Castro, R., Kowatsch, T., Filler, A., Dey, M., Schaub, M. P. (2016). Efficacy of a Web- and Text Messaging-Based Intervention to Reduce Problem Drinking in Adolescents: Results of a Cluster-Randomized Controlled Trial. *Journal of Consulting and Clinical Psychology, 85(2)*:147-159.

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Haug, S., Paz Castro, R., Kwon, M., Filler, A., Kowatsch, T., & Schaub, M.P. (2015). Smartphone use and smartphone addiction among young people in Switzerland. *Journal of Behavioral Addictions, 4(4)*: 299-307.

Haug, S., Schaub, M. P., Paz Castro, R., & Schmid, H. (2014). Barrieren und Ressourcen für einen Rauchstopp bei Auszubildenden. *Sucht - Zeitschrift für Wissenschaft und Praxis, 60(4)*:225-234.

Haug, S., Kowatsch, T., Paz Castro, R., Filler, A., & Schaub, M. P. (2014). Efficacy of a web- and text messaging-based intervention to reduce problem drinking in young people: study protocol of a cluster-randomised controlled trial. *BMC Public Health, 14(1)*:809.

Haug, S., Paz Castro, R., Filler, A., Kowatsch, T., Fleisch, E., & Schaub, M. P. (2014). Efficacy of an internet and SMS-based integrated smoking cessation and alcohol intervention for smoking cessation in young people: study protocol of a two-arm cluster randomised controlled trial. *BMC Public Health, 14(1140)*:online.

Selected oral contributions

Paz Castro, R. & Haug, S. (2017). Adolescents engagement with an Internet- and mobile phone-based smoking cessation program. Talk at the *31th Conference of the European Health Psychology Society (EHPS)*, 29 August- 2 September, Padova, Italy

Paz Castro, R., & Haug, S. (2017). Förderung der Lebenskompetenz bei Jugendlichen via Mobiltelefon. Workshop at the *conference of the Kantonales Netzwerk gesundheitsfördernder Schulen*, 8th April, 2017, Schlosszentrum Au (Zurich), Switzerland.

Paz Castro, R., Haug, S., & Schaub, M.P. (2017). Efficacy of a web- and text messaging-based intervention to reduce problem drinking in adolescents: Results of a cluster-randomised controlled trial. Talk at the 2nd *Competence for Mental Health Symposium (CCMH)*, 26th January, 2017, University of Zurich, Switzerland.

Haug, S. & Paz Castro, R. (2016). Suchtprävention im schulischen Setting mit Hilfe des Mobiltelefons - Ergebnisse bisheriger Studien und neue Entwicklungen. Talk at the *Scientific Colloquium of the Swiss Research Institute for Public Health and Addiction ISGF*, 5th December, 2016, ARUD Zurich, Switzerland.

Haug, S. & Paz Castro, R. (2016). MobileCoach Alcohol- Efficacy of a web- and text messaging-based intervention to reduce problem drinking in adolescents. Talk at the *13th INEBRIA conference*, September 22-23, 2016, CHUV Lausanne, Switzerland.

Paz Castro, R., Haug, S., & Schaub, M.P. (2016). Efficacy of a web- and text messaging-based intervention to reduce problem drinking in adolescents: Results of a cluster-randomised controlled trial. Talk at the *19th Conference of the European Association for Substance Abuse and Addiction Research (EASAR)*, May 19–22, 2016, Middelfart, Denmark.

Paz Castro, R., & Haug, S. (2015). Transitions of stages of change in text message-based tailored interventions and success in smoking cessation. Talk at the *18th Conference of the European Association for Substance Abuse and Addiction Research (EASAR)*, May 7-10, 2015, University of Bangor (Wales), UK.

Ad-hoc Peer Reviews

BMC Public Health Journal

BMC Substance Abuse Treatment, Prevention, and Policy

JBA Journal of Behavioral Addictions

Addiction Research & Theory

AJPM American Journal of Preventive Medicine

Grant & Award

03.2016	Travel grant from the doctoral programme of the University of Zurich (UZH) for assisting the *19th Conference of the European Association for Substance Abuse and Addiction Research (EASAR)*, May 19–22, 2016, Middelfart, Denmark
10.2013	Semester award from the University of Zurich (UZH) for the master thesis "*Belastungen in Familien mit chronisch kranken Kindern: Die Rolle der gemeinsamen Zeit als Schutzfaktor*"